AIR POLLUTION CONTROL

IN TULSA, OKLAHOMA:

A CASE STUDY

By

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PREFACE

My interest in Tulsa's air quality programs began in January 1995, when I joined the Indian Nations Council of Governments (INCOG) as an air quality intern. INCOG provides planning services to member governments throughout a five county region in northeastern Oklahoma and serves as the administrator of the *Ozone Alert!* program. My employment with INCOG provided much of the background and inspiration to perform this case study.

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NOMENCLATURE

CAA	Clean Air Act
CAAA	Clean Air Act Amendments
CMAQ	Congestion Mitigation-Air Quality
EPA	U.S. Environmental Protection Agency
I/M	inspection and maintenance
INCOG	Indian Nations Council of Governments
MACT	maximum available control technology
NAAQS	national ambient air quality standards
NOx	nitrogen oxides
O_3	ozone
PM	particulate matter
ppm	parts per million
psi	pounds per square inch
SIP	state implementation plan
VOCs	volatile organic compounds

CHAPTER I

INTRODUCTION

Reaching Great Britain decades earlier, the industrial revolution began in full force in the United States in the late 1800s, sparking unprecedented economic and technological growth. Industrial and technological expansion meant urbanization: more and more people moved to America's cities, with hopes of finding well-paying industrial jobs. Factories produced material goods at a rapid pace to serve the ever increasing urban population. Coal-burning power plants generated electricity to reach every American home. Rapid industrial activity and population and income expansion continued through the early 1900s. During that time, the automobile was introduced, allowing people the freedom to live and work many miles apart. After the Great Depression, industrial activity again inflated with wartime production. After World War II, the exploding population moved away from the central business districts to the outlying suburbs. As a result, people relied on the automobile for transportation more than ever.

Urbanization and the industrial and technological expansion of the late 1800s and 1900s raised the standard of living in the United States to the highest level in the world. The widespread use of the automobile throughout the twentieth century gave the American people the personal freedom to live and raise their families in quiet neighborhoods miles away from busy cities. But the rapid industrial, technological, and economic progress experienced in the United States over the last century has not come without a price: environmental pollution.

The environment consists of all the natural and human-made surroundings in which we live. Commonly, the word "environment" brings to mind natural objects such as forests, rivers, and streams. But humans and our behavior, including economic, technical, political, and cultural activities, comprise and influence the earth's environment as well. Increasingly, humans are adding more of the by-products from industrial activities, transportation, the production of goods, and various other activities into the planet's water, ground, and air than it can handle.

While waterways have been used for centuries to dispose of human waste products, disposal through dilution is only effective to a certain point. Following World War II, industrial production expanded and numerous synthetic chemicals were developed. As a result, many lakes, streams, and rivers became chemical dumping grounds and highly polluted. In fact, the Cuyahoga River flowing through Cleveland, Ohio, was filled with so many flammable chemicals that in 1969 it caught on fire and consumed seven bridges before burning out (Cable & Cable, 1995).

Although flaming rivers are extreme examples of our country's water pollution problems, surface and groundwater contamination is prevalent in the United States. In fact, nearly forty percent of the nation's surface waters tested by the U.S. Environmental Protection Agency (EPA) do not meet federal water quality standards (U.S. EPA, 1994). Groundwater throughout the United States is contaminated by leaking underground storage tanks, agricultural runoff, Superfund sites, and septic tanks (U.S. EPA, 1994).

Not only is water pollution a problem in the United States, the nation's soils and land resources are becoming increasingly contaminated as well. With industrial and technological expansion, the amount of material goods per capita in the United States has

skyrocketed since World War II (Schwartz, 1993). The disposal of these goods has become a major concern. According to the EPA, Americans produced 208 million tons of refuse (municipal solid waste) in 1995, or 4.3 pounds per person per day (U. S. EPA, 1996a). Each person in the United States discarded 3.2 pounds of such waste each day (U.S. EPA, 1996a). Americans also produce 279 million tons of hazardous waste each year (U.S. EPA, 1997). Many laws tightly regulate the transportation, treatment, storage, and disposal of wastes today. But it took tragic events, such as high incidences of illnesses and birth defects in a neighborhood built upon a chemical dump site in Love Canal, New York, to bring waste disposal issues to the attention of lawmakers and the public in the 1970s and early 1980s (Cable & Cable, 1995).

Another issue that first received broad-based federal attention in the 1970s is air pollution. As early as the 1800s, major cities throughout the United States enacted ordinances to control smoke stemming from the numerous coal-burning factories. After World War II, the Los Angeles, California basin began experiencing and locally regulating a different form of air pollution: photochemical smog. Tropospheric or ground-level ozone is the major component of photochemical smog.

Although the federal government enacted legislation to help state and local governments operate air pollution control programs throughout the 1950s and 1960s, the Clean Air Act Amendments (CAAA) of 1970 and 1977 represented the first large-scale federal effort to curb air pollution. This legislation called for the development of federal health-based air quality standards and stipulated control measures for areas that did not meet the standards.

The Clean Air Act Amendments of 1990 gave the federal government an even stronger role in air pollution regulation. Federal control of acid rain and the protection of the stratospheric ozone layer are addressed for the first time. The legislation focuses particularly on the reduction of tropospheric ozone. Regulatory measures such as stricter controls on industry, automobiles, and the production of cleaner-burning gasoline are mandated in certain areas to control the pollutant.

Since the 1970s, the level of air pollution in the United States has decreased drastically, mainly due to control technology on previously unregulated industries and automobiles (U.S. EPA, 1996b). For example, ambient lead levels decreased by seventy-eight percent from 1986 to 1995 (U.S. EPA, 1996b). The health-based standard for tropospheric ozone, however, continues to be exceeded in all major urban areas.

The Problem

Throughout the 1980s, Tulsa, Oklahoma did not meet the federal health-based standards for tropospheric ozone. In 1990, however, the Environmental Protection Agency (EPA) reclassified the area as attaining the standard since no exceedances of federal limits had occurred over the previous three years. Local political and business leaders viewed this change as crucial to the area's continued economic development. Tulsa experienced an exceedance of the federal ozone standard on June 24, 1991, however. As a result, the Indian Nations Council of Governments (INCOG) Air Quality Committee developed and implemented the *Ozone Alert!* program. This program relies on voluntary efforts by local governments, business and industry, and citizens to reduce

air pollution on days when meteorological conditions are conducive to forming high levels of ozone.

In spite of the voluntary pollution reduction measures implemented as part of the *Ozone Alert!* program and industrial mandates under the Clean Air Act, Tulsa continues to exceed federal ozone limits. If voluntary efforts fail to reduce local ozone levels, Tulsa could face strict and costly pollution control measures. An area that is not in compliance with federal air quality standards may experience a decrease in economic development and growth. For example, businesses and industries may choose not to locate in the area, as they may be mandated to install costly pollution prevention equipment and programs. Additionally, residents may be discouraged from locating in areas with excessive air pollution due to the risk of adverse health effects.

Purpose of the Study

The following provides a descriptive case study of Tulsa, Oklahoma's *Ozone Alert!* program and related air pollution control efforts. A comparative analysis is performed to measure the local air quality programs with similar programs in cities throughout the United States. Based on this analysis, recommendations are given as to how to improve Tulsa's air quality programs.

The reader is provided with a brief background on the history of air pollution and air quality regulations, and a closer look at ozone, including formation, meteorological effects, and transport issues in Chapter II. Chapter III describes the methodology of the study, including research design, data collection, and limitations of the study. An overview of Tulsa's *Ozone Alert!* program and other local air pollution control strategies

is contained in Chapter IV. Chapter V reports the findings of the comparative analysis and offers recommendations for future studies. Finally, Chapter VI provides a summary and conclusion to the case study.

Conclusion

Throughout the 1990s, the environment has received much attention: the Clean Air Act Amendments of 1990 represent the largest piece of environmental legislation to date; "environmentalist" Al Gore was elected Vice-President in 1992 and re-elected in 1996; and the twenty-fifth anniversary of Earth Day was celebrated in 1995. Air pollution, in particular, has been the subject of much controversy and debate. In Tulsa, the major air quality concern is ozone. Citizens, health and environmental groups, businesses, industries, and state, local, and federal governments share an interest in the control of this pollutant; whether for health, economic, or aesthetic concerns. Due to the current pro-environment executive administration, environmentally wary legislative majority, and the highly publicized controversy over the recently revised air quality standards, the debate over ozone, air pollution, and the environment in general, will rage on into the twenty-first century.

CHAPTER II

REVIEW OF THE LITERATURE

A Brief History of Air Pollution in the United States and Abroad

> In the early Middle Ages it was a mark of distinction to have plumes of smoke continually issuing from every chimney of a chateau, for only the rich could afford the luxury of using fuel wastefully. Then came the industrial revolution and the time when the prosperity of a community was often gauged by the number of exhaust stacks belching black smoke. Now, however, attitudes are changing. Warmth and sustenance are taken for granted; health and aesthetics occupy a higher position in our list of priorities. Befouling the air is no longer praised or acceptable. (Williamson, 1973, p. 400).

According to Williamson (1973), air pollution is "the presence in the atmosphere of a substance or substances added directly or indirectly by an act of man, in such amounts as to affect humans, animals, vegetation, or materials adversely" (p. 1). Natural sources of air pollution result from volcano eruptions, dust storms, and swamps (Hill & Kolb, 1995). While some forms of man-made pollution, such as tropospheric ozone, have only recently been noted, smoke pollution has plagued humans, plants, and animals for hundreds, even thousands of years (Hill & Kolb; Williamson).

Several examples of air pollution have been documented throughout history. According to Hill and Kolb (1995), the author Seneca described the "stink, soot, and heavy air" of Rome as early as A.D. 61 (p. 344). The Queen of England moved from the

city of Nottingham in 1257 due to the heavy smoke (Hill & Kolb; Te Brake, 1975). Due to its odor and smoke, coal burning was banned during sessions of Parliament by King Edward I in the 1300s (Williamson, 1973; Te Brake). In the late 1500s, Queen Elizabeth I complained to Parliament about the heavy smoke hovering over London (Williamson; Te Brake). In the United States during the late 1800s and early 1900s, citizen complaints about air pollution frequently revolved around aesthetic and visibility concerns as well (National Association of Counties Research Foundation [NACRF], 1966). Ultimately, however, citizens accepted reduced visibility and smoke-stained clothes as representing "progress" and economic security due to the industrial revolution (NACRF). Unfortunately, citizens soon learned that air pollution was more than an aesthetic nuisance.

Historically, air pollution has at times served as a deadly killer on a large scale. The first modern large scale pollution incident occurred in Belgium's Meuse Valley in December 1930 (Perkins, 1974; Smith, 1995). Over sixty people perished due to a thermal inversion--a stagnant, warm upper layer of air over a cool lower layer--that trapped a variety of industrial pollutants in the low-lying valley (Hill & Kolb, 1995). In October of 1948, twenty people died and 6,000 became ill when smog settled in the valley of Donora, Pennsylvania for three days (Cooper & Alley, 1994; Perkins; Smith). According to one report, a layer of sulfur and zinc particulates so thick that "footprints and tire tracks [were] visible in it" settled over the valley (Hill & Kolb, p. 343).

Eight thousand London residents died in December 1952, when an inversion of sulfur dioxide and other pollutants hovered over the British city (Perkins, 1974; Smith, 1995). As Hill and Kolb (1995) note, the London air pollution disaster claimed more

lives than were ever lost "in any single tornado, mine disaster, shipwreck, or plane crash" (p. 347). The following year, a severe pollution event caused 200 people to die in New York City (Perkins). In 1962, another killer fog invaded London, causing nearly 750 deaths (Perkins).

The "smog" often blanketing the city of London and responsible for the aforementioned incidents of large scale pollution-related deaths is the combination of "smoke and fog" (Cooper & Alley, 1994). Often this smog mixture contains sulfur dioxide, particulates, carbon monoxide, and other pollutants stemming from coal-burning industrial sources (Cooper & Alley). These pollutants, together with meteorological conditions such as thermal inversions, historically have led to tragic incidents of death and illness. More recently, a different form of "smog" that some argue causes tens of thousands of illnesses and deaths each year has begun to plague urban areas throughout the world.

Ozone

Ozone, or photochemical smog, first became problematic in Los Angeles, shortly after the end of World War II (Public Health Service, 1967). Due to the area's geographic and meteorological characteristics, as well as a rapidly increasing population that relied solely on the automobile for transportation through the sprawling region, a brownish haze frequently covered the basin from late morning to mid-afternoon (Public Health Service). Today, ozone is found in nearly every major urban city in the world. Smith (1995) notes that nearly sixty percent of the population in Calcutta, India, suffer air pollution-related diseases. Taipei, New Delhi, Sao Paulo, Mexico City, and Cairo all

have serious air pollution problems as well (Smith; Underwood, 1996). In the United States, the Environmental Protection Agency (EPA) estimates that over 70 million people live in areas that do not meet federal ozone standards (U.S. EPA, 1996b).

Formation

The air pollutant ozone refers to tropospheric or ground-level ozone, not to be confused with stratospheric ozone. Stratospheric ozone, formed through natural processes, provides a shield thirteen to thirty miles above the earth (Brewer, 1988; Hunton & Williams, 1993; Skinner & Porter, 1992). The ozone layer is formed when intense sunlight causes oxygen molecules (O_2) to break up and reform as unstable ozone (O_3) molecules (Brewer).

$$\underset{\text{Oxygen atom}}{O} + \underset{\text{Oxygen molecule}}{O_2} \xrightarrow{\text{sunlight}} \underset{\text{Ozone}}{O_3}$$

Stratospheric ozone shields humans, plants, and animals from the dangerous ultraviolet (UV) rays of the sun. Excessive exposure to UV radiation can cause such things as skin cancer, cataracts, and problems to the immune system (U.S. EPA, 1993). In absorbing the ultraviolet radiation, the ozone is converted back to oxygen molecules and oxygen atoms, thereby reversing the previous reaction (Brewer, 1988).

$$O_3 \xrightarrow[\text{radiation}]{\text{ultraviolet}} O + O_2$$

Chlorofluorocarbons (CFCs), formerly found in products such as air conditioners and hair spray, are being phased out due to evidence indicating that they damage the stratospheric ozone layer. CFCs diffuse into the stratosphere, where they are broken

down by ultraviolet radiation. Chlorine atoms, formed as a result of this process, decompose stratospheric ozone (Hill & Kolb, 1995).

$$CF_2Cl_2 + \text{ultraviolet radiation} \longrightarrow CF_2Cl^{\cdot} + Cl^{\cdot}$$

$$Cl^{\cdot} + O_3 \longrightarrow Cl^{\cdot}O + O_2$$

$$Cl^{\cdot}O + O \longrightarrow Cl^{\cdot} + O_2$$

This process can be repeated several times, resulting in the destruction of many stratospheric ozone molecules due to one molecule of chlorofluorocarbon.

While stratospheric ozone is naturally occurring, tropospheric or ground-level ozone is largely formed through human activities. Ozone is a secondary pollutant resulting from photochemical reactions in the lower atmosphere. Secondary pollutants, such as ozone, are not directly emitted into the atmosphere, but result from the reaction of other pollutants.

A complex reaction of volatile organic compounds (VOCs), including hydrocarbons, and nitrogen oxides (NOx) with sunlight forms ozone.

$$VOCs + NO_x \xrightarrow{\text{sunlight}} O_3$$

Primarily man-made pollutants, VOCs emerge from such things as automobile emissions, solvents, gasoline vapors, chemical manufacturing, dry cleaning, petroleum refining, and fossil fuel combustion (Cooper & Alley, 1994). In addition, urbanization can also cause high levels of VOCs due to urban heat islands--areas of paved roadways and tall buildings with little or no vegetation--with increased temperatures (Chameides & Cowling, 1995). Natural biogenic sources such as trees also emit hydrocarbons, a component of VOCs, into the atmosphere (U.S. EPA, 1993).

Nitrogen oxides (NOx), the other ozone precursor, result from the combustion of fossil fuels in engines and industry, particularly electric power plants (Tulsa City-County Health Department [TCCHD], 1994). Automobiles are the greatest source of NOx emissions among mobile sources. Other sources of NOx emissions are "off-road" gasoline- and diesel-powered engines such as lawnmowers, boats, and generators (State and Territorial Air Pollution Program Administrators [STAPPA] & Association of Local Air Pollution Control Officials [ALAPCO], 1993). Additionally, the application of nitrogen fertilizers to soils represents a significant source of NOx emissions, particularly in agricultural areas (Chameides & Cowling, 1995). NOx also occurs naturally from lightning (Chameides & Cowling).

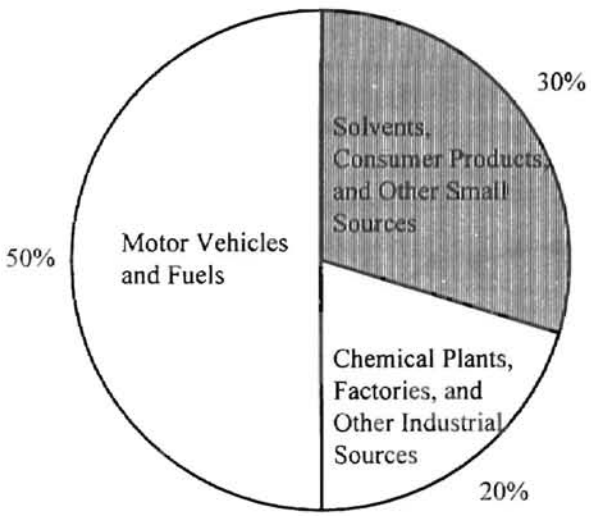

Figure 1. Manmade Sources of VOCs and NOx (U.S. EPA, 1997)

Meteorology

The formation of tropospheric ozone involves many meteorological variables. Ozone formation occurs with minimal wind levels, as wind tends to dissipate VOC and NOx concentrations. Additionally, rain can physically "wash out" the ozone precursors from the air, therefore high ozone levels occur only on days with no rainfall.

Since ozone formation is dependent upon sunlight, pollutant concentrations are minimal at sunrise, peak in the early afternoon, and fall to minimal levels again after sunset (see Figure 1). Ozone levels follow a seasonal pattern as well. In the United States, conditions are most conducive to ozone formation from May through early October, when sunlight is most intense and temperatures are elevated.

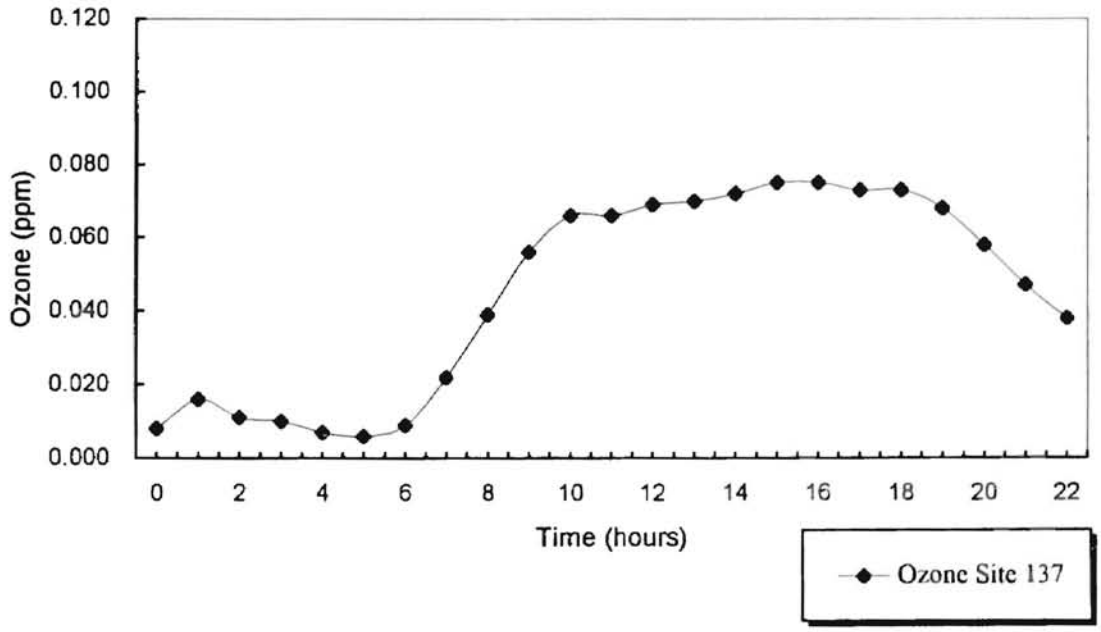

Figure 2. Typical Daily Ozone Level Fluctuations in Tulsa, Oklahoma
June 21, 1994

Transport

Air pollution does not remain within state boundaries. Pollutants traveling from outside areas may place an economic burden on other areas due to clean-up costs. Most scientists agree that ozone and its precursors can travel hundreds of miles from their source before dissipating (U.S. EPA, 1996b; Chameides & Cowling, 1995). The Clean Air Act Amendments of 1990 recognized this phenomenon in developing the Ozone Transport Commission (OTC). The OTC is composed of the District of Columbia, Virginia, Maryland, Delaware, Pennsylvania, New Jersey, New York, New Hampshire, Massachusetts, Maine, Vermont, and Rhode Island. Each of these states is in noncompliance with current health-based air quality standards, although some of these regions may only suffer from poor air quality due to transport from other states, namely industrialized regions of the Mid-west.

The issue of air pollution transport is also being studied at the Grand Canyon National Park. The Clean Air Act Amendments of 1990 created the Grand Canyon Visibility Transport Commission to study the effects of transport. A recent report prepared in conjunction with the Commission suggests that "good visibility days in the [Grand Canyon National Park] are sensitive to the level of emissions in this region" (Green & Gebhart, 1997, p. 403).

As more studies are conducted by groups such as the Ozone Transport Commission and the Grand Canyon Visibility Transport Commission, ozone transport can be better understood. With increased knowledge of the phenomenon, air pollution

control measures can be implemented that do not unfairly financially burden areas receiving the transported pollution.

Health Effects

While it is generally agreed that ozone can cause adverse human health effects including wheezing, shortness of breath, and chest irritation, the severity of these effects is the subject of much debate. In drafting the Clean Air Act Amendments of 1990, the Senate noted that "the health problem [associated with air pollution] is serious and it is pervasive. There is no choice but to breathe the air, whether it is clean or polluted. Air is inhaled regardless of its quality" (U.S. Senate, 1989, p. 3). Health organizations, such as the American Lung Association, maintain that the health effects of ozone can be very serious, especially for children and people with asthma (American Lung Association [ALA], 1995). The American Lung Association (1995) estimates that over 27.1 million children aged thirteen and under and 1.9 million asthmatic children live in areas with "unhealthy" levels of ozone pollution. In a recent study, the American Academy of Pediatrics concludes that ozone increases the lung problems of asthmatic children (Schmitzberger et. al., 1993). Other studies note that ozone has a more significant adverse effect on those with preexisting respiratory infections (Ostro, Lipsett, Mann, Krupnick, & Harrington, 1993; Cody, Weisel, Birnbaum, & Lioy, 1992).

Many studies correlate increased incidents of respiratory-related emergency room visits with air pollution levels at or below the current national ambient air quality standards (NAAQS). One study notes positive associations between hospital visits and ozone and sulfates at levels below the current NAAQS (Burnett et al., 1994). Another

study reports emergency room visits in Atlanta increased by thirty-seven percent following periods when ozone levels met or exceeded 0.111 ppm, a level lower than the current 0.124 ppm one-hour maximum standard for ozone (White, Etzel, Wilcox & Lloyd, 1994).

Ozone is detrimental to plant life as well (U.S. EPA, 1993). By reacting with plant cellulose, ozone causes cellular collapse and a reduction in carbon dioxide fixation rates. Cellular damage appears as spots on the leaves of plants. Ozone is believed to reduce world-wide crop yields by five to ten percent annually (Lowe, 1990).

While many studies illustrate that potential adverse health effects of air pollution, particularly ozone, others suggest that "scant evidence" exists that the current NAAQS do not adequately protect public health and welfare (Beck, 1997, p. 30). A study by the Center for the Study of American Businesses indicates that many studies finding adverse health effects at ozone levels below 0.125 ppm are unreliable and "inconclusive," citing "inconsistent scientific data" ("Business Study," 1992, p. 40).

Some health studies show that even at levels below federal limits, ozone does not adversely affect human health. For example, one study conducted in Los Angeles shows a negative correlation between high ozone levels and frequency of asthma attacks and hospital admissions (Richards, W., Azen, S., Weiss, J., Stocking, S., & Church, J., 1981). Another study conducted in Vancouver failed to show any correlation between hospital visits and ozone levels (Bates, D.V., & Sizto, R., 1986).

The debate over the health effects of air pollutants, particularly ozone, continues in light of the EPA's proposal in 1996 to revise the NAAQS for ozone and particulate matter. Health and environmental groups support tighter limits for the pollutants while

most businesses and some political entities argue that no reliable scientific evidence exists to support stricter air quality standards (Corn, 1997). As more studies are conducted and data are collected, perhaps the line between healthy and unhealthy levels of pollution will become clearer.

Air Quality Legislation Overview

Although the level at which to control air pollution continues to be the subject of heated debate, it has generally been the consensus in the United States that pollution should be controlled, if not for health reasons then for aesthetic concerns. Air pollution stemming from the combustion of coal and other fossil fuels increased tremendously in the United States with the industrial revolution in the late 1800s. Early legislative efforts to control air pollution focused on smoke and odor control. For instance, Chicago and Cincinnati passed smoke control ordinances in 1881 (Schwartz, 1993). By the early 1900s, twenty-three of the largest twenty-eight cities in the United States had passed similar ordinances (Schwartz). With increased urbanization and the appearance of photochemical smog in cities throughout the country after World War II, air pollution regulatory measures greatly increased on local, state, and federal levels.

Prior to 1955, the U.S. Bureau of Mines studied smoke control and smelter fume and gas abatement (National Association of Counties Research Foundation [NACRF], 1966). Additionally, the U.S Public Health Service conducted a few limited air pollution control studies (NACRF). The Air Pollution Control Act of 1955 (69 Stat. 322), however, represented the first federal effort to address air pollution control in the United States (Cooper & Alley, 1994; Hunton & Williams, 1993; NACRF; Williamson, 1973).

The Act did not "control" air pollution, but provided $25 million over a five year period for research on the sources, nature, concentration, and control of air pollutants. The Act also provided for technical assistance to state and local governments (NACRF). In 1960, Congress approved an additional four years of funding for the Act and called for the Surgeon General to study the effects of motor vehicle exhausts on human health (NACRF).

The Air Pollution Control Act of 1955 was not a federal control effort to reduce air pollution. Its intent was only to provide state and local lawmakers with the tools and technical assistance to continue to implement air pollution control programs locally.

After reviewing an intensive study of air pollution by the Senate Committee on Public Works, Congress indicated that the primary responsibility for the regulation of air quality should continue to remain at the state and local government level (NACRF, 1966). As a result, Congress passed the Clean Air Act of 1963 (PL 88-206, 77 Stat. 392) to provide federal financial assistance and leadership for the development of cooperative federal, state, regional, and local programs to prevent and control air pollution. Specifically, the Act authorized the following: research on the removal of sulfur from fuels; development of emission control devices; the creation of a technical committee to study motor vehicle pollution; stronger control measures for federal facilities causing pollution; and development of air quality criteria.

While air pollution control was delegated to state and local governments under the Clean Air Act, the federal government recognized that pollution did not conform to political boundaries. Therefore, the Act allowed provisions for federal intervention in interstate air pollution abatement (NACRF, 1966).

In 1965, Congress passed the Motor Vehicle Air Pollution Control Act (PL 89-272, 79 Stat. 992). This legislation established the first federal program for the regulation of emissions from new motor vehicles. Emissions limits were first set for 1968 model automobiles, based on 1965 technology. But, the law reserved the right to tighten emissions controls as technology improved (Cooper & Alley, 1994).

The Air Quality Act of 1967 (PL 90-148, 42 U.S.C. §§ 1857 et seq. 1967) extended the federal government's role in research and development of air pollution controls. The Act also required the Secretary of the Department of Health, Education, and Welfare to designate air quality control regions to facilitate regional planning and pollution control efforts and promulgate air quality "criteria" to describe the health and welfare effects of pollutants. While the federal government was charged with developing air quality criteria, air pollution control continued to be viewed as the responsibility of local governments. Consequently, air quality standards based on federal criteria were developed and enforced by state and local governments.

The Clean Air Act Amendments of 1970 (PL 91-604, 42 U.S.C. §§ 1857 et. seq. 1970) gave the federal government a stronger role in air quality regulation. The Amendments directed the EPA to establish national ambient air quality standards (NAAQS), based on federal air quality criteria. These standards, specifying maximum acceptable levels of pollutants for outdoor air, are to be applied nationwide, unless an area promulgates standards more stringent than the federal standards.

NAAQS are divided into two categories: primary standards and secondary standards. Primary standards set limits that protect human health, without regard for control costs. Secondary standards protect the public well-being, including non-health

effects such as visibility and aesthetic concerns, and economic effects such as crop damage (Cooper & Alley, 1994). The NAAQS encompass six criteria pollutants: carbon monoxide (CO), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), particulate matter of ten microns and less (PM-10), lead (Pb) (added in 1978), and ozone (O_3). Table 1 lists the primary and secondary standards for the six criteria pollutants as of June 1996.

TABLE I

NATIONAL AMBIENT AIR QUALITY STANDARDS

Criteria Pollutants	Annual Average	1 Hour Maximum	3 Hour Maximum	8 Hour Maximum	24 Hour Maximum	Calendar Quarter
Primary Standards						
Sulfur Dioxide (SO_2)	0.031 ppm				0.144 ppm	
Particulate Matter ≤ 10 microns (PM-10)	50 $\mu g/m^3$				150 $\mu g/m^3$	
Carbon Monoxide (CO)		35 ppm		9 ppm		
Ozone (O_3)		0.124 ppm				
Nitrogen Dioxide (NO_2)	0.053 ppm					
Lead (Pb)						1.5 $\mu g/m^3$
Secondary Standards						
Sulfur Dioxide (SO_2)			0.5 ppm			
Particulate Matter ≤ 10 microns (PM-10)	50 $\mu g/m^3$				150 $\mu g/m^3$	
Carbon Monoxide (CO)		35 ppm		9 ppm		
Ozone (O_3)		0.124 ppm				
Nitrogen Dioxide (NO_2)	0.053 ppm					
Lead (Pb)						1.5 $\mu g/m^3$

Source: 40 CFR 50.4-50.12

The Clean Air Act Amendments (CAAA) of 1970 outlined federal enforcement procedures if states failed to meet NAAQS. The Act explicitly gave states control of most air pollution abatement activities, however (Perkins, 1974). States were required to describe their pollution abatement activities in state implementation plans (SIPs), submitted to the EPA within three years. If the state did not submit a plan, the EPA could develop a pollution reduction plan for the state to implement.

The CAAA of 1970 also imposed federal automobile emissions controls. As Cooper and Alley (1994) note, this is the first example of technology-forcing legislation. The automobile industry claimed it would be impossible to meet emissions standards set out by the Amendments due to lack of available technology (Schwartz, 1993). By 1975, however, the catalytic converter was introduced, consequently reducing hydrocarbon and CO emissions by ninety percent and NOx emissions by seventy-five percent (Schwartz).

In 1977, the Clean Air Act was amended again. The CAAA of 1977 (PL 95-55, 42 U.S.C. § 7401 et seq.) broadened the goals of federal air quality policy and further defined the EPA's role in implementing the Act (Hunton & Williams, 1993). Preserving unpolluted air was a major theme of the 1977 Amendments (Hunton & Williams). For example, provisions were made for the protection of air quality in national parks and a prevention of significant deterioration (PSD) program was implemented. The PSD program prevented the air quality in areas classified as "pristine" from deteriorating, even if such increases in polluting emissions would still allow the area to remain within the limits of NAAQS.

According to Hunton and Williams (1993), beginning with the CAAA of 1977, "Congress began to use the Clean Air Act as a tool for addressing social policy" (p. 5). For example, to protect the jobs of high-sulfur coal miners, the CAAA of 1977 required the installation of sulfur dioxide scrubber systems on newly constructed fossil fuel-burning boilers (Hunton & Williams).

The Clean Air Act Amendments of 1990

Described by former President Bush as "simply the most significant air pollution legislation in our nation's history," the Clean Air Act Amendments of 1990 (PL 101-549, 104 Stat. 2399) resulted in tremendous changes to the Clean Air Act ("After 10-Year," 1990, p. 7A). Nearly 800 pages long, the CAAA of 1990 consist of eleven titles addressing several aspects of air pollution regulation, including urban areas, mobile sources, air toxics, acid deposition, and stratospheric ozone protection.

As explained in Title I (§ 100) of the CAAA of 1990, geographic areas meeting NAAQS are classified as attainment areas, while those that do not meet the standards are classified as nonattainment areas. Nonattainment areas must perform certain mandated actions to improve air quality. If these measures are not taken, the federal government has the discretion to impose economic sanctions such as withholding federal highway funding.

The pollutants addressed by Title I include ozone, carbon monoxide, and particulate matter. Ozone nonattainment areas are divided into six categories based on the severity of pollution levels and deadlines for reaching clean-up goals. "Marginal" ozone nonattainment areas (0.125 to 0.137 ppm) have three years to meet the standard. "Moderate" nonattainment areas (0.138 to 0.159 ppm) must meet the standard in six years. Areas classified as "serious" (0.160 to 0.179 ppm) have nine years to meet the NAAQS for ozone. "Severe 1" areas (0.180 to 0.270 ppm) must meet the standard in fifteen years, while "severe 2" areas have seventeen years to meet the standard. Finally, areas are classified as "extreme" if ozone levels exceed 0.280 ppm, and have twenty years

to meet the NAAQS for ozone. Table 2 lists the all of the serious and above ozone nonattainment areas established by the CAAA of 1990 and examples of the moderate and marginal nonattainment areas.

TABLE II

OZONE NONATTAINMENT AREAS AS DESIGNATED BY THE CAAA OF 1990

EXTREME

Los Angeles-South Coast Air Basin, CA

SEVERE 2

Chicago-Gary-Lake County, IL-IN	New York-New Jersey-Long Island, NY-NJ-CT
Houston-Galveston-Brazoria, TX	Southeast Desert Modified-Air Quality Maintenance Area, CA
Milwaukee-Racine, WI	

SEVERE 1

Baltimore, MD	San Diego, CA
Philadelphia-Wilmington-Trenton, PA-NJ-DE-MD	Ventura County, CA

SERIOUS

Atlanta, GA	Boston-Lawrence-Worcester, MA-NH	Portsmouth-Dover-Rochester, NH	San Joaquin Valley, CA
Baton Rouge, LA	El Paso, TX	State of Rhode Island	Springfield, MA
Beaumont-Port Arthur, TX	Greater Connecticut	Sacramento Metro, CA	Washington, DC-MD-VA

MODERATE

Many areas in the Northeastern United States including Atlantic City, NJ and parts of Maine; areas in the South and Mid-Atlantic states including Charlotte-Gastonia, NC, Miami, FL, and Richmond, VA; industrial areas including parts of Ohio, Kentucky, and West Virginia; and areas in the West and Southwest including Dallas-Ft. Worth, TX, Phoenix, AZ, and many areas in California.

MARGINAL

Marginal areas stretch across the country from New York and Pennsylvania, down the Atlantic coast to Tampa FL, across the Mid-west through Indianapolis, IN and parts of Illinois, to the Northwestern states of Oregon and Washington.

Mandated ozone abatement activities, as required by Title I, increase in stringency with each nonattainment classification. While marginal areas must only perform an updated emissions inventory and impose stronger controls on industry, areas classified as moderate and above must submit a plan to the EPA demonstrating how emissions of VOCs will be reduced by fifteen percent within three years. Additionally, moderate and above areas must implement inspection and maintenance (I/M) programs to identify

vehicles that do not meet emissions standards (STAPPA & ALAPCO, 1993). Areas designated as severe or extreme nonattainment must use cleaner-burning reformulated gasoline (STAPPA & ALAPCO). According to the CAAA of 1990, severe and extreme nonattainment areas are also required to implement employee commute option (ECO) programs (§ 182(d)(1)(B)). Under ECO programs, employers with 100 or more employees are to increase the average passenger occupancy per employee vehicle by twenty-five percent. This can be accomplished through carpool and vanpool programs, subsidized transit fares, and the institution of compressed work weeks or telecommuting (work at home) options. Los Angeles, the only area designated as an extreme nonattainment area, must introduce non-polluting electric cars into the region, as well.

Due to the large amount of air pollution emitted by mobile sources, Title II (§ 200) of the CAAA of 1990 deals exclusively with such sources. This legislation requires that tailpipe emissions standards for automobiles be strengthened. Cleaner burning fuels such as "reformulated gasoline" and alternative fuel programs are required for some areas. Diesel fuel sulfur content is reduced and lead is banned from all motor fuel use.

Title III (§ 300) addresses hazardous air pollutants or air toxics. Although the EPA was required to list hazardous air pollutants beginning with the Clean Air Act Amendments of 1970, the agency only listed and regulated seven such toxics by 1990 (U.S. EPA, 1993). Therefore, Congress listed 189 air toxics in the CAAA of 1990. Under Title III, certain sources are required to install maximum achievable control technology (MACT) to reduce air toxic emissions by ninety percent by the year 2000.

Title IV (§ 400) is designed to reduce acid deposition, commonly known as acid rain. Acid rain can damage buildings and vegetation, and kill fish and other benthic

organisms by raising the pH of lakes and streams to uninhabitable levels (Skinner & Porter, 1992). The primary precursors to acid deposition are sulfur dioxide (SO_2) and nitrogen oxides (NOx). Therefore, the regulation of SO_2 and NOx serves as the cornerstone of Title IV. The CAAA of 1990 call for nationwide SO_2 emissions reductions, primarily from coal-burning electric utilities. Standards for NOx emissions must also be set under Title IV. A market-based allowance system for SO_2 reductions has been developed to help reduce levels of the pollutant by over fifty percent by the year 2000.

Title V (§ 500) creates a federal air pollution permit program for large industrial sources. Previously, only thirty-five states operated permit programs (U.S. EPA, 1993). Each major pollution source must have an operating permit that specifies its compliance requirements, including information on the pollutants and quantities released, as well as monitoring programs. The permits are granted for a fixed term. States collect fees from permittees to cover program costs.

Title VI (§ 600) tackles the problem of stratospheric ozone depletion. While tropospheric ozone is a criteria air pollutant regulated under Title I, stratospheric ozone shields the earth from dangerous ultraviolet radiation. Title VI develops a phase-out schedule for chlorofluorocarbons (CFCs), halons, hydrochlorofluorocarbons, and carbon tetrachloride, substances that breakdown the stratospheric ozone layer.

Title VII (§ 700) deals with enforcement of the Clean Air Act Amendments of 1990. Administrative, civil, and criminal penalties for violators of the Act range from fines of thousands of dollars per day to several years imprisonment. Additionally, Title

VII allows the EPA to reward a "bounty" of $10,000 to anyone providing information on CAAA violations leading to a penalty or conviction.

Various miscellaneous provisions to the Clean Air Act Amendments of 1990 are addressed in Title VIII (§ 800). Provisions include the establishment of a program to monitor and improve air quality along the border between the United States and Mexico; a study to determine the environmental impacts of the combustion of contaminated used oil in ships; and a report on the incremental health and environmental benefits versus the incremental costs of the control strategies and technologies in the CAAA.

Title IX (§ 900) addresses clean air research. Provisions include an assessment of international air pollution control technologies; a program to research the effects of acid deposition on waters where acid deposition has been most acute; and annual and periodic assessment reports on acid deposition in western states.

Title X (§ 1000) of the Clean Air Act Amendments of 1990 deals with disadvantaged business concerns. For any research relating to the CAAA requirements using EPA funds, ten percent of such funding is to be made available to disadvantaged businesses, including those owned by women, minorities, and disabled Americans.

The final section of the Clean Air Act Amendments of 1990, Title XI (§ 1100), undertakes the issue of employment transition for workers who are "dislocated" due to compliance with the Act. Title XI provides for assistance such as job training, grants, and relocation allowances.

The Clean Air Act Amendments of 1990 represent the most lengthy and comprehensive environmental legislation enacted to date. Through its eleven titles, the requirements of the CAAA of 1990 impact business, industry, state and local

government, and citizens. With such a diverse group of interests impacted sharply by the Act, it is no surprise that implementing the CAAA of 1990 has been highly controversial and costly.

Costs Associated with Meeting CAAA of 1990 Requirements. When the CAAA of 1990 were signed into law by former President Bush in November 1990, the EPA estimated that implementing the legislation would cost American businesses, industries, and taxpayers $25 billion per year ("After 10-Year," 1990). Thus, many of the financially affected parties were not endeared to the clean air cause. The costs associated with ozone control, and air pollution in general, have always been controversial. For example, in the 1950s the automobile industry maintained that exhausts emitted into the atmosphere by vehicles "[did] not present an air pollution problem" (Smith, 1995, p.71). Later, the automobile industry conceded that automobiles did pollute somewhat, however, industry officials argued that pollution control was highly expensive. Indeed, air pollution control cost the automobile industry approximately $18 billion in the 1980s (Smith). Consequently, emissions of some pollutants have been reduced by over ninety percent since 1970 (Smith).

As the automobile industry was forced to pay for pollution control devices on vehicles, businesses must pay for employee commute option (ECO) programs and states must pay for inspection and maintenance (I/M) programs. For instance, businesses must subsidize parking for employees who carpool or vanpool and provide bus passes to public transportation users in order to comply with ECO programs. I/M programs raise the price

of an annual state safety inspection by nine to seventeen dollars (STAPPA & ALAPCO, 1993).

Ultimately, consumers pay for these programs and pollution control strategies through higher prices and higher taxes. Consequently, citizens pressure their representatives due to the price they must pay for the "burdensome" environmental regulations. Additionally, representatives are pressured by corporations who do not want to experience a drop in profit due to pollution control policies. Representatives also realize that due to the North American Free Trade Agreement (NAFTA), businesses may transplant to environmental restriction-free foreign countries (Pribitkin, 1994). Such relocations could lead to job losses and reduced economic prosperity for an area, events that are not conducive to the reelection of legislators.

Resistance to Implementation. Inspection and maintenance (I/M) programs, employee commute option (ECO) programs, and nonattainment area requirements are just a few examples of costly policies, designed to reduce air pollution, which have recently been suspended by the Environmental Protection Agency (EPA). Additionally, the EPA failed to respond to calls for a revision of the ozone standard in 1992, although the agency proposed a more stringent standard in November 1996. If the Clean Air Act was passed to ensure public health, why are policies not being implemented to realize this goal?

In part, the EPA relaxed inspection and maintenance (I/M) program requirements and suspended mandated employee commute option (ECO) programs in response to political pressure. Specifically, the House Commerce Committee began hearings on

February 9, 1995, to examine controversial Clean Air Act issues ("EPA Says," 1995). Additionally, five bills were introduced in January 1995, calling for delay, and in some cases repeal, of I/M program and ECO requirements ("EPA Says", 1995). Some states have refused to implement I/M programs because of expense and public outcry. Some cities, such as Houston, refused to follow the mandated employee commute option program due to the burden and expense the program places on businesses.

The Environmental Protection Agency's budget has undergone substantial cuts in recent years. For example, the EPA's budget for 1993 was $240.8 million less than originally expected (Pribitkin, 1994). With such budget cuts, enforcement of regulations, such as ECO programs and I/M programs becomes increasingly difficult. Coupled with business and industry resistance and political resistance to such programs, some argue that the EPA has succumbed to relaxing its position on environmental policies (Pribitkin).

Revisions to the NAAQS for Ozone. On November 27, 1996, the EPA announced its proposed revisions to the ozone and particulate matter NAAQS (Myers, 1996b; Clark, 1996). The proposed revisions were published in the Federal Register on December 13, 1996 (61 FR 65716). The EPA proposes to replace the current 0.125 ppm one-hour one-exceedance standard for ozone with a standard of 0.08 ppm averaged over eight hours, using the third highest ozone concentration each year for three years. For particulate matter, the EPA proposes two new primary standards for fine particles and will revise the existing twenty-four hour standard regulating PM-10. The law specifies that the EPA set air quality standards based on health considerations, not the associated costs or economic impacts. Even the EPA, however, admits that the changes, if enacted,

could have far reaching consequences (Myers, 1996a). The increase in the number of areas that would fall into nonattainment for either PM or ozone or both would be substantial.

Few groups seem pleased with the proposal. Environmentalists feel that the EPA is putting government and industry concerns over public health concerns in proposing an 0.08 ppm ozone standard instead of a more protective 0.07 ppm standard (White, 1997). States, local governments, and industry believe the EPA is going too far to appease environmental interests, without adequate scientific evidence to support such revisions (Corn, 1997). As a result, corporate interests have mounted an intense lobbying effort to fight the revisions (Corn).

Congress and others are concerned about the costs associated with the proposed changes in the standards and the regulatory burden that would be placed on states and metropolitan areas. Steve Largent and Tom Coburn, U.S. Representatives from Oklahoma, warn that "a change in the [ozone] standard" would put "northeast Oklahoma in the same category as Los Angeles, Chicago, New York and other nonattainment areas, while not having better air quality to show for it" (Myers, 1996b, p. A1). Additionally Largent and Coburn are concerned that the air quality standard change would harm local businesses (Myers, 1996b). U.S. Senator (representing Oklahoma) Jim Inhofe, Chairman of the subcommittee charged with oversight of clean air issues, including the proposed NAAQS revisions, also questions the need for such sweeping changes (Myers, 1996a)

Under the revised air quality standards, Tulsa County would remain in attainment for particulate matter but fall into nonattainment for ozone (Clark, 1996). Comanche, Kay, Muskogee, and Oklahoma Counties would also face nonattainment designation for

the pollutant ozone (Clark). Many other areas throughout the United States currently in compliance with air quality standards will become nonattainment areas if the proposed NAAQS revisions take effect. Along with revised standards, the EPA will also develop revised implementation measures and compliance deadlines. Health and environmental groups, business and industry, and government officials anxiously await the announcement of the final NAAQS, scheduled for July of 1997, and the subsequent requirements and deadlines for compliance.

The Role of Risk Assessment and the Courts in Determining Air Quality Standards

After lawsuits by environmental and health groups, the EPA proposed more stringent NAAQS for the criteria pollutants ozone and particulate matter in November 1996 (61 FR 65716). Both historically and in the most recent revisions to the air quality standards, data express extreme discrepancies in health risks associated with air pollutants. The following will examine the uncertainty and variability in assessing risk from air pollutants and the controversial role the courts have played in determining the acceptability of such risks.

The Review Process for Air Quality Standards

Review of the national ambient air quality standards (NAAQS) consists of the following: a review of the pollutant's chemistry and other scientific issues as outlined in the "criteria document"; a "staff paper" containing the EPA's recommendation for the range of the air quality standard and justifications for their recommendation; publication of the proposed rule in the Federal Register; a public comment period; and the

publication of the final NAAQS in the Federal Register (Wolff, 1996). Some find this process to be "inadequate" since the process does not generate standards that "maximize the net benefits (i.e. benefits less costs) to society" (Viscusi, 1982, p. 686). Others, however, maintain that the EPA does not go far enough in setting air quality standards that adequately protect human health (Corn, 1997; White, 1997).

Those that view the current NAAQS review process as failing to adequately account for costs to business and industry, point to the development of the lead standard. Those that maintain that the EPA sets NAAQS in the interest of business and industry rather than public health cite the Agency's refusal to revise the ozone standard in 1992.

The Development of the Lead Standard. The current NAAQS for lead is 1.5 micrograms per cubic meter of air. The EPA determined the standard by calculating the threshold above which 99.5 percent of the most sensitive population would be protected. With the phase-out of lead in gasoline in the 1970s and 1980s, the lead standard now focuses on industrial stationary sources. Some maintain that the EPA's policy of not considering cost when setting the lead standard puts too much burden on industry and does not address the true problems associated with the pollutant (Viscusi, 1982).

For example, since the lead standard is uniform for all states, variables such as size of affected population and compliance costs are not considered. Therefore, some believe that "any regional variation in the implications of lead emissions will make it desirable to have different lead standards rather than a uniform national standard" (Viscusi, 1982, p. 688). Claims of inadequacy are furthered since the standard deals with levels of lead in the ambient air instead of in the human blood where it is truly of concern

(Viscusi). Moreover, the lead standard is criticized because the threshold dose-response model used in determining the standard is highly uncertain (Viscusi). Proponents of the standard, however, point to the ninety percent decrease in ambient lead since the standard's adoption in 1978 (Smith, 1995).

The Controversial Ozone Standard. In setting the NAAQS for lead, the EPA was criticized for not considering economic consequences. In determining the ozone standard, however, the Agency was criticized for catering to economic concerns of business and industry. In 1992, the American Lung Association sued the EPA for failing to review the NAAQS for ozone (American Lung Association v. Reilly, 141 F.R.D. 19). After a court-ordered review, the EPA concluded that the standard adequately protects human health. Although health and environmental groups agree that the current ozone standard is too high, the EPA resisted lowering the standard.[1] Pribitkin (1994) asserts this is because "it is the governmental agencies and businesses, not the health and environmental groups, that would bear the financial burden associated with reducing ozone" (p. 115). Additionally, Pribitkin notes that the North American Free Trade Agreement (NAFTA) allows American companies to operate in foreign countries that have little or no pollution regulations. Due to loss of profits from higher compliance costs, "an increase in ozone restrictions could become an inconvenience that businesses can easily solve by transplanting factories and corporations to other countries" (Pribitkin, 1994, p. 116).

[1]EPA has since proposed to strengthen the NAAQS for ozone and particulate matter, as announced by Administrator Carol Browner on November 27, 1996 (Myers, 1996a; Clark, 1996) and published in the Federal Register on December 13, 1996 (61 FR 65716).

Some also argue that the EPA opposed changing the ozone standard in 1992 due to budget cuts within the agency that hamper enforcement capabilities (Pribitkin, 1994). A recent study, however, counters the assertion that bureaucracies are highly influenced by political interests (Wood, 1988). Following the principal-agent model, it was hypothesized that due to the adverse conditions imposed by the Reagan administration, the EPA would reduce its air quality monitoring and pollution abatement activities. Since the opposite occurred and monitoring and abatement activities increased during this period, it was determined that "considerations of hierarchy, although important, have obvious limitations for explaining outcomes in some implementation policy processes" (Wood, 1988, p. 227). The study concluded that while the election of Reagan in 1980 and his pledge to "tame the EPA monster" did result in substantial, agency-wide cuts in budget, staff, and enforcement ability, these cuts did not lead to reduced air quality monitoring and pollution abatement activities (Wood, 1988, p. 219).

Cost Versus Health: Can a Compromise be Made?

Is it possible to adequately protect public health while setting air quality standards that do not disproportionately burden industry financially and are not influenced by the current political climate? According to a recent study involving particulate matter, not only can health risks due to the pollutant be lowered, but compliance costs can be reduced as well.

The study determined that while the current NAAQS of 150$\mu g/m^3$ averaged over twenty-four hours may be met, one-hour concentrations greater than the NAAQS for

particulate matter can occur (Michaels, 1996). According to Michaels (1996), toxicological literature supports the assertion that short-term exposure to high levels of particulate matter can cause adverse health effects since "brief exposures during air pollution excursions are followed by prolonged internal exposures in lungs which cannot efficiently clear fine particles" (p. 729). Therefore, the study concludes that the EPA should revise the particulate standard to an averaging time of one hour because not only is a shorter averaging time more protective of health, but is economically feasible since it would "primarily affect equipment start-up and shutdown rather than constant facility operation" that the twenty-four hour averaging time covers (Michaels, p. 735).

If put into action for particulate matter, the study mentioned above could prove to be an example of both business and health interests being satisfied with the levels at which air quality standards are set. For now, however, the EPA will continue to be criticized for catering too much to business and industry interests and disregarding health and environmental issues or vice versa. Therefore, these conflicts must be settled by an outside arbiter: the courts.

The Role of the Judiciary in Setting Air Quality Standards

For the pollutants lead and ozone, the EPA's process of setting air quality standards is highly controversial. Another controversial aspect of the regulatory review process is when the judiciary must become involved in the process (Hoban & Brooks, 1987). As in the case of the American Lung Association's suit against the EPA, at times the courts are called upon to make judgments on technical issues that can affect public health and safety. Probably the most cited example of the judiciary making risk

judgments is found in *Natural Resources Defense Council v. United States Environmental Protection Agency* (824 F.291146, 1987), a case involving the regulation of vinyl chloride (Travis & Hattemer-Frey, 1988; Marchant & Danzeisen, 1989). In this case, the U.S. Circuit Court of Appeals for the District of Columbia held that the EPA must identify an acceptable level of risk for chemical carcinogens regulated by section 112 of the Clean Air Act. To determine acceptable risk, the court required the EPA to first determine an acceptable level of emissions "without regard to cost or technical feasibility" (Travis & Hattemer-Frey, p. 873). After this "safe" level of risk is established, the EPA is allowed to consider other items to determine a risk level that affords an "ample margin of safety to protect public health" (Travis & Hattemer-Frey, p. 873).

With the proliferation of environmental legislation throughout the 1970s and subsequent challenges by business and industry, the role of the judiciary in environmental and human health issues broadened (Vig & Bruer, 1982). Vig and Bruer (1982) argue that these regulations established risk assessment as a "general responsibility" of government for the first time, but acknowledge that the legislation "did not establish any uniform policy toward risk/benefit balancing or standards of regulation" (p. 716). Thus, the courts have had to "interpret Congressional intent concerning different hazards, and to resolve disputes over application of the laws" (Vig & Bruer, p. 716). Many of the regulations are written such that standards must be reviewed by the courts. The judiciary is divided over this role as social guardian because it must make decisions on technical issues which are wrought with uncertainty and disagreement among even the so-called experts (Vig & Bruer).

Cost Versus Health: *Should* a Compromise be Made?

If a compromise can be made and air quality standards can be set so they protect public health while not putting an unfair financial burden on industry, is this desirable? Cropper and Oates (1992) call for a shift from the "purist" method of setting air quality standards based solely on health concerns to a more "realistic consideration of the designation and implementation of policy measures" incorporating economic concerns (p. 676). The courts have upheld the EPA's policy that protection of human health and the environment should be the top priority when setting air quality standards. Although even when costs or technological feasibility are not considered and air quality standards are determined solely on the basis of health, the current models used to predict risk levels are highly uncertain. The public should be informed of this uncertainty and involved in the decision-making process from the very beginning. Currently, however, the process of developing NAAQS only invites public comment in one of its final stages.

Business and industry advocates maintain that the current regulatory policies dealing with risk impose societal costs that far outweigh benefits. Citing the EPA's development of the lead standard, these groups assert that "meaningful reform of risk regulation requires not only the establishment of further benefit-cost requirements . . . but also a revision of the regulatory agencies' legislative mandates so that these tradeoffs will be recognized in the design and implementation of policies" (Viscusi, 1982, p. 690).

Conversely, health and environmental groups argue that the EPA is more concerned with protecting the financial interests of business and industry than protecting human health and the environment when setting air quality standards. These groups point

to the EPA's failure to strengthen the ozone standard in 1992, after a court-ordered review, as proof of their allegiance to commercial interests. In addition, some health and environmental groups maintain that the EPA lets political issues affect their decisions. However, studies counter this assertion by showing that the EPA indeed performs its required actions regardless of the political climate (Wood, 1988).

At times, the courts have been called upon to determine air quality standards and make judgments as to the acceptable levels of risk due to air pollutants. As with the other facets of setting air quality standards, the role of the judiciary has been mired in controversy as in the "vinyl chloride" decision (Travis & Hattemer-Frey, 1988; Marchant & Danzeisen, 1989).

While solutions or compromises to make the process of setting air quality standards smoother may be offered (as in the study involving particulates), ultimately those that are most affected by air pollution--the public--should be allowed a stronger role in the determination of what level of risk is acceptable. The current practice of allowing the "experts" determine risk acceptability omits the input of the very people whose health the standards are intended to protect.

Conclusion

Complaints regarding smoke and odor from the burning of wood and coal date back thousands of years. This "smog" was responsible for the several incidents of large scale pollution-related deaths in the 1900s (Cooper & Alley, 1994). Often this smog mixture contains sulfur dioxide, particulates, carbon monoxide, and other pollutants stemming from coal-burning industrial sources (Cooper & Alley). Since World War II

and the increased use of the automobile, a different form of "smog" has come to the forefront that some argue causes tens of thousands of illnesses and deaths each year.

Photochemical smog or ozone first became a problem in the Los Angeles, California basin in the 1940s. Now, every major city in the world is plagued with ground-level ozone problems. Ozone forms from the reaction of volatile organic compounds (VOCs) and nitrogen oxides (NOx) in the presence of sunlight.

Although state and federal legislation to control air pollution has been implemented in the United States since the early 1900s, the Clean Air Act Amendments (CAAA) of 1990 represent the most sweeping air quality regulations to date. The legislation, covering issues from acid rain to ground-level ozone, is estimated to cost $25 billion per year to implement. Due to the high costs associated with the CAAA of 1990 and the controversy surrounding the health effects of the regulated air pollutants, the implementation of the legislation has been highly controversial.

At times, the courts have been asked to determine air quality standards and make judgments as to the acceptable levels of risk due to air pollutants. As with the other facets of setting air quality standards, the role of the judiciary has been highly controversial as well.

While solutions or compromises to make the process of setting air quality standards smoother may be offered, ultimately those that are most affected by air pollution--the public--should be allowed a stronger role in the determination of what level of risk is acceptable. Then perhaps the costs of attaining such levels will be easier to swallow by legislators, business, and industry.

CHAPTER III

METHODOLOGY

Introduction

Although the *Ozone Alert!* program is designed to reduce air pollution in Tulsa, Oklahoma, thereby maintaining attainment status, the area continues to exceed the national ambient air quality standards (NAAQS) for ozone. Since the program's implementation in 1991, the Tulsa area has remained in attainment for the criteria pollutant ozone. With the exception of 1992, however, the area continues to exceed the NAAQS for ozone each year. Without the flexible attainment region agreement of 1995, the area could be designated a marginal nonattainment area for ozone if the standard is exceeded three times in 1997 at any of the three local ozone monitoring stations. Table III lists the exceedances of the ozone standard that the Tulsa area has experienced since 1991.

TABLE III

OZONE EXCEEDANCES (1991 - 1996)
TULSA, OKLAHOMA

MONITORING STATION	1991	1992	1993	1994	1995	1996
Site 127	0.134 6/24	--	--	0.132 0.129 6/21 6/22	--	0.131 7/02
Site 137	0.131 6/24	--	0.128 8/13	0.143 6/22	0.127 8/25	--
Site 174	--	--	--	--	0.150 8/27	--

As the Tulsa area continues to experience levels of ozone pollution above federal limits, the effectiveness of the current air pollution reduction programs becomes questionable. Therefore, a comparative analysis is performed to measure the local air quality programs with similar programs in cities throughout the United States. Based on this analysis, recommendations are given as to how to improve Tulsa's air quality programs.

Research Design

Beginning with the Clean Air Act Amendments of 1970 and continuing with the Act's most recent 1990 Amendments, areas in the United States that do not meet national ambient air quality standards (NAAQS) for certain criteria air pollutants are classified as nonattainment areas. Nonattainment areas must implement pollution reduction measures and attain NAAQS by specified deadlines or face economic sanctions such as the loss of highway funding. Several nonattainment cities throughout the country implement voluntary pollution reduction programs in addition to mandated measures in an attempt to attain the NAAQS. Some attainment cities, such as Tulsa, implement voluntary air pollution reduction programs in order to prevent nonattainment designation.

At the current time, no studies exist to quantify the effectiveness of Tulsa's voluntary ozone reduction program, although two surveys were conducted in 1995 to measure the level of participation by businesses in the *Ozone Alert!* program. Ultimately, Tulsa determines the success or failure of the *Ozone Alert!* program by whether the area continues to meet ozone standards or if the air quality deteriorates to the point that the

area is designated as a nonattainment area for the pollutant. Therefore, this descriptive case study of Tulsa's air pollution reduction programs employs a comparative analysis methodology to gauge the effectiveness of the local program. Recommendations for further programs and studies resulting from this analysis are directed toward the agencies involved in administering voluntary ozone reduction programs, lawmakers, and citizens as ways of achieving continued compliance with air quality standards.

Date Collection and Sources

The bulk of the data used in the case study are unpublished informal reports, inter-office memoranda, and educational materials developed by the agencies coordinating Tulsa's *Ozone Alert!* program and organizations that implement similar programs in cities throughout the United States. The local reports were obtained as a result of the author's employment with the Indian Nations Council of Governments (INCOG), however, INCOG and other agencies involved in the coordination of air pollution reduction programs share various reports and information with members of the general public upon request. The following provides a detailed list of data sources compiled for this study.

1. Inter-office Reports, Staff Papers, and Memoranda

   Inter-office reports, staff papers, and memoranda prepared by the Tulsa City-County Health Department, INCOG, the INCOG Air Quality Committee, the Metropolitan Tulsa Transit Authority, and the Oklahoma Department of Environmental Quality on several aspects of the *Ozone Alert!* program and the economic consequences of nonattainment designation on Tulsa, Oklahoma, were obtained through the air quality staff person at INCOG.

2. Interviews

The author conducted interviews on the local *Ozone Alert!* program with members of INCOG's air quality and environmental staff, air quality technicians with the Oklahoma Department of Environmental Quality and the Tulsa City-County Health Department, and staff members of the Metropolitan Tulsa Transit Authority throughout the period of June 1995 through December 1996. From June 1996 through August 1996, the author contacted representatives from the National Association of Regional Councils and the thirty-two cities that operate voluntary, episodic ozone control programs.

3. *Ozone Alert!* Employer Participation Surveys

In March 1995, in conjunction with her employment with INCOG, the author prepared and sent an *Ozone Alert!* information packet to 1399 local businesses with greater than ten employees, registered with the Metropolitan Tulsa Chamber of Commerce. The packet included an "*Ozone Alert!* Employer Participation Survey and Fax Notification" form. The businesses were to return the form so INCOG could gain a better insight into the level of participation in the program. Of the 1399 forms mailed, only eighty-five were returned. The survey and results are located in Appendix A. A discussion of the results is found in Chapter V.

In July 1995, again in conjunction with her employment with INCOG, the author developed and distributed another survey to 150 local businesses and organizations participating in the *Ozone Alert!* fax notification system to gauge their level of participation in the program. Forty-two companies responded to the survey. The

survey and results are located in Appendix B. A discussion of the results is found in Chapter V.

4. Surveys to Determine Participation in Voluntary Air Quality Programs in Other Cities

Two INCOG staff members attended the "National Voluntary Ozone Control Conference," in Austin, Texas, November 13-14, 1995, sponsored by the Texas Natural Resource Conservation Commission. INCOG staff returned from the conference with several unpublished reports, including information on surveys conducted in Dallas, Kansas City, Southeast Michigan, and Washington, DC. The author used these reports for this case study.

5. Ozone Monitoring Data

Hourly ozone concentrations from each of the three ozone monitoring stations located in the Tulsa area were provided to the author by the Tulsa City-County Health Department and the Oklahoma Department of Environmental Quality.

6. Traffic Data

The author used hourly traffic counts, vehicle miles traveled, and other traffic-related data provided by INCOG and the Oklahoma Department of Transportation in the study.

7. Mobile Source Emissions Data

MOBILE 5A is the current computer model approved by the EPA to determine the amount of emissions reductions produced by implementing certain control measures on mobile sources, namely automobiles. INCOG, as the Tulsa area's metropolitan planning organization, is required by the EPA to use MOBILE 5A to

determine local mobile source emissions reductions for Oklahoma's state implementation plan (SIP). This study includes MOBILE 5A data provided by INCOG.

8. Published Reports, Periodicals, and Government Documents

The author used the resources from the Tulsa City-County Library and several public and private university libraries in this study.

Limitations of the Study

This work serves as a comprehensive case study of Tulsa's *Ozone Alert!* program and comparative analysis with other ozone reduction programs, based largely on unpublished data and interviews with the agencies charged with implementing the programs. The author's employment with the Indian Nation's Council of Governments (INCOG), the program's principal implementing agency, has resulted in the inclusion of many internal studies and reports on the *Ozone Alert!* program. This study serves as a comparison of Tulsa's *Ozone Alert!* program with other similar voluntary programs and offers suggestions for possible program improvement based on the examination of other programs and studies.

Recent work by the North American Research Strategy for Tropospheric Ozone (NARSTO) indicates that high levels of ozone pollution may never be controlled by voluntary and even some mandated measures (Travis, G., personal communication, October 14, 1996). Factors such as weather, geography, and natural sources of VOCs and NOx may play a greater role in determining ozone levels than scientists originally believed. The Southern Oxidants Study found that reducing the level of VOC emissions,

as mandated by the Clean Air Act (and implemented voluntarily in the Tulsa area), may be contributing to ozone pollution in Georgia, rather than reducing pollution (Chameides & Cowlings, 1995). Due to the large number of pine trees emitting nitrogen oxides (NOx) in the region, the study recommends ozone pollution measures focusing on the reduction of NOx (Chameides & Cowlings).

While these factors may very well contribute to Tulsa's ozone pollution problems, such issues are beyond the scope of the present study due to limits in time, technical expertise, and funding. These points, however, should be addressed in future studies, especially as Tulsa develops the Tulsa Ozone Prevention Strategy (TOPS) as part of the flexible attainment region agreement with the EPA.

CHAPTER IV

OVERVIEW OF TULSA'S *OZONE ALERT!* PROGRAM AND OTHER AIR POLLUTION CONTROL STRATEGIES

History of Tulsa's *Ozone Alert!* Program Development

While never in danger of being classified as a nonattainment area for the other five criteria air pollutants, Tulsa was classified as a nonattainment area for ozone in the 1980s. Tulsa was redesignated an attainment area for ozone in November 1990, after no violations of the NAAQS were recorded during the previous three year period. Following an exceedance of the ozone standard on June 24, 1991, the Indian Nations Council of Governments (INCOG) Air Quality Committee was created. The INCOG Air Quality Committee is a partnership among local governments, business, industry, health groups, and environmental organizations. The Committee developed and implemented *Ozone Alert!*; a program consisting of voluntary efforts on an "as needed" basis by local governments, business and industry, and citizens to improve local air quality and maintain Tulsa's attainment status. In spite of the pollution reduction measures implemented under the *Ozone Alert!* program, Tulsa has experienced seven exceedances of the ozone standard since June 1991. In fact, the area could be redesignated a marginal nonattainment area for ozone if the standard is exceeded three times in 1997 at any of the three local ozone monitoring stations.

Tulsa's *Ozone Alert!* program, the first of its kind in the United States, has been replicated by many attainment and nonattainment cities. In fact, as of December 1996, thirty-two such programs exist throughout the United States. Tulsa's *Ozone Alert!*

program has received many environmental awards including the National Public Transportation Innovation Award for Metropolitan Planning Organization Program Excellence in 1991 and the U.S. Environmental Protection Agency Administrator's Award for Regional Finalists in 1992. In 1993, the program received the American Lung Association of Green Country Oklahoma, George W. Prothro, M.D. award and the State of Oklahoma Governor's Environmental Excellence Award. The *Ozone Alert!* program also received the University of Oklahoma College of Public Health, Dan J. Macer Environmental Stewardship Award in 1994.

Monitoring

Tulsa's ozone levels are monitored at three local stations, maintained by the Oklahoma Department of Environmental Quality. Station 174 is the southern-most monitoring station, located in Glenpool. Station 127 is located on Mohawk Boulevard, just east of Tulsa International Airport. Site 137 is located north of Tulsa in Skiatook. The EPA requires that monitoring stations be located in the areas where highest ozone levels are likely to occur. Thus, Tulsa's monitors are placed accordingly, due to the following conditions: 1) hydrocarbons, emitted from naturally occurring sources such as trees, enter south Tulsa County; 2) industrial emissions containing VOCs NOx stem from a large number of facilities, including two refineries and a power plant located in south and west Tulsa County; 3) vehicle exhaust emissions containing VOCs and NOx form from the high traffic density located in downtown Tulsa; and 4) winds blow predominantly from the south and southwest. These four factors lead to the current placement of Tulsa's three ozone monitors.

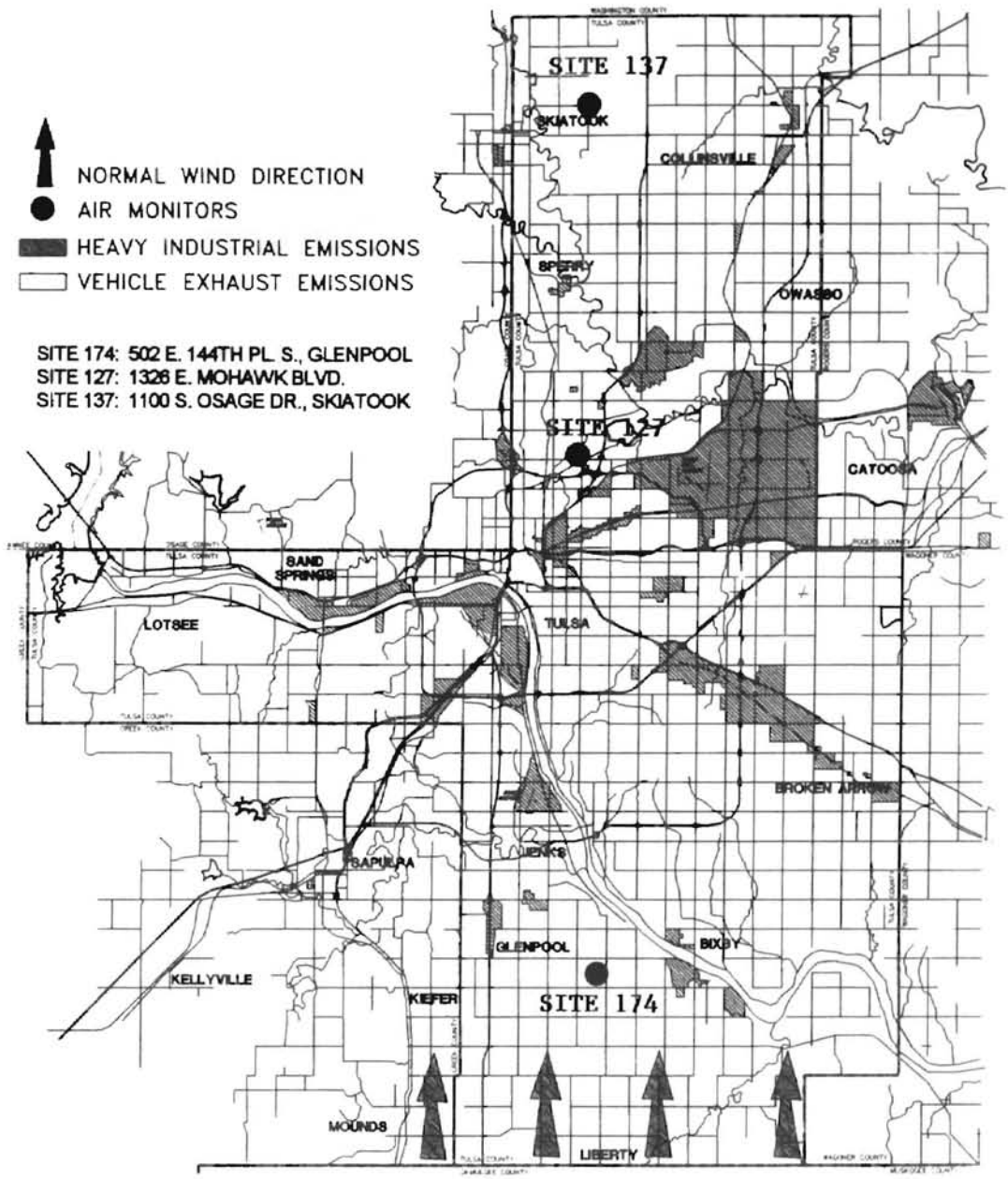

Figure 3. Ozone Monitoring Stations in Tulsa County

The monitoring stations measure ozone levels using ultraviolet absorption (Tulsa City-County Health Department [TCCHD], 1994). An ozone-free reference sample passes through the absorption cell to establish a "zero" light reading (I_o). Next, an

ambient air sample flows through the absorption cell to establish a "sample" light intensity (I). The ratio of these two readings (I/I_o) is a measure of the light absorbed by ozone in the sample at 254 nanometers (nm). The ratio is directly related to the concentration of ozone in the sample through the Beer-Lambert Law:

$$I/I_o = e^{-\epsilon LC}$$

Where: ϵ = 308 centimeters (cm) at 0°C (degrees Centigrade) and 1 atm (atmosphere of pressure)
L = length of cell in centimeters
C = concentration in parts per million (ppm)

Criteria for Determining an *Ozone Alert!* Day

The implementation of the *Ozone Alert!* program begins with the accurate prediction of the onset of meteorological conditions favorable to the formation of high ozone concentrations, at least one day in advance. This allows sufficient lead time for the publicity campaign aspect of the program. The Tulsa City-County Health Department,[2] in collaboration with the National Weather Service, developed a model to predict days when high ozone levels could potentially occur. The model considers the following factors: temperature, wind speed and direction, cloud cover, and frontal passage. Figure 2 is the actual matrix by which the Oklahoma Department of Environmental Quality's Regional Office at Tulsa (ODEQ-ROAT) determines *Ozone Alert!* days. In addition to these factors, ODEQ-ROAT takes into consideration the level of ozone from the previous day.

[2] The Tulsa City-County Health Department's Air Quality Section of the Environmental Health Services Division was an original partner in developing the *Ozone Alert!* program. In 1995, all of the Air Quality Section's personnel and activities were transferred to the Oklahoma Department of Environmental Quality's Regional Office at Tulsa (ODEQ-ROAT).

WIND DIRECTIONS	WIND SPEED (MPH)	TEMPERATURE (F)	CLOUD COVER (% <)	FRONTAL PASSAGE	PREDICTION (03)
VARIABLE	0–5	92 TO 99	20	NONE	PROBABLE
S–SW	6–10	92–98	30	NONE	POSSIBLE
S–SW	0–10	95–91 OR 99–105	20	NONE	POSSIBLE
S TO N & N TO S	0–10	88–100	30	EARLY AFTERNOON	PROBABLE

Figure 4. Meteorological Conditions for Declaring an *Ozone Alert!* Day

Ozone Alert! Program Highlights

Since the program's creation in 1991, many public and private entities in Tulsa have identified and implemented voluntary initiatives to improve air quality as part of the *Ozone Alert!* program. The *Ozone Alert!* program is administered by the Indian Nations Council of Governments (INCOG), in cooperation with the City of Tulsa, Tulsa County, the ODEQ-ROAT, and other entities.

On *Ozone Alert!* days, the public is urged to limit driving, mowing, and refueling. Program administrators believe this voluntary, episodic approach to ozone pollution control is more readily accepted by the public than mandated, long term actions. Thus, the *Ozone Alert!* program consists of voluntary efforts by public and private entities on an "as needed" basis.

Gasoline Suppliers and Retailers. Since 1992, local gasoline suppliers have voluntarily provided reduced Reid vapor pressure (RVP) gasoline in the Tulsa area during the ozone season. Gasoline with lower vapor pressure evaporates more slowly and emits fewer hydrocarbons into the atmosphere. Hydrocarbons, a form of volatile organic compounds (VOCs), are key components in the formation of ozone. In 1995, gasoline RVP averaged 8.3 pounds per square inch (psi) or less, whereas gasoline for the Tulsa area is only required by the EPA to maintain an average RVP of 9.0 psi. According to the EPA-approved Mobile5A emissions model, gasoline with RVP of 8.3 psi reduces hydrocarbons by over four tons per day compared to gasoline with RVP of 9.0 psi (internal INCOG report, 1996).

Local gasoline retailers post "thumbs-up" posters and "pump toppers" on *Ozone Alert!* days requesting motorists not to refuel or wait until evening hours to do so. By not refueling, evaporative emissions, such as hydrocarbons, are not released into the atmosphere and do not contribute to ozone formation. Since sunlight is essential to the formation of ozone, refueling in the evening reduces the likelihood of evaporative emissions forming ozone. In addition to posters and "pump toppers," gasoline retailers provide *Ozone Alert!* informational brochures to the public during the ozone season. The pump toppers and brochures are printed under the supervision of INCOG, funded through private donations.

Local Businesses. Tulsa area businesses have voluntarily created *Ozone Alert!* programs within their companies. For example, some local companies award employees

that carpool to work with "prime" parking places, t-shirts, and movie passes. Others create special editions of company newsletters to inform employees about ozone.

To encourage such efforts by local employers, INCOG maintains an *Ozone Alert!* fax notification system. In 1996, over 300 local companies and organizations with a total of over 90,000 employees received fax notification the afternoon before an *Ozone Alert!* day. Additionally, at the beginning of each ozone season, local employers are invited to an informational workshop, sponsored by the Metropolitan Tulsa Chamber of Commerce and INCOG, to assist in the planning and implementation of company *Ozone Alert!* programs.

The INCOG Air Quality Committee has taken many other efforts to encourage the participation of local businesses in the program. For example, information, including "Tips on Marketing Your Company's *Ozone Alert!* Program," was mailed to nearly 1400 local companies in 1995. In addition, representatives from INCOG, the INCOG Air Quality Committee Speaker's Bureau, the City of Tulsa, and the Metropolitan Tulsa Transit Authority are available to speak at local companies about the *Ozone Alert!* program and offer assistance in forming company-wide programs.

School Education. Believing that early and continued education is vital in encouraging participation in pollution reduction activities, the INCOG Air Quality Committee implements an on-going student education program in elementary and secondary schools throughout Tulsa County. The *Ozone Alert!* poster contest has been conducted since 1993 to educate students and their families about the *Ozone Alert!* program. Additionally, educational materials about ozone formation and the *Ozone*

Alert! program, including an informational video, have been placed in faculty libraries in schools throughout Tulsa County, to assist educators with air pollution education.

Public Education. Educating the general public about ozone pollution is also an integral part of the *Ozone Alert!* program. Local print and television media give ample coverage to *Ozone Alert!* program activities during the summer months and inform the public of upcoming *Ozone Alert!* days. Additionally, the INCOG Air Quality Committee Speaker's Bureau meets with various civic groups and organizations about the *Ozone Alert!* program, in an effort to further educate the public on air quality issues. A video and public service announcements describing Tulsa's *Ozone Alert!* program are also used in the INCOG Air Quality Committee's publicity campaign.

Mowing. Due to a lack of emissions standards, the use of gasoline-powered lawn and garden equipment is a major contributor of ozone-forming pollutants. In fact, the amount of hydrocarbon and NOx emissions stemming from one hour of lawn mower operation is equivalent to the amount of emissions released when driving a car from Dallas to New York (U.S. Department of Transportation, 1996). Therefore, an effort to reduce the use of such equipment on *Ozone Alert!* days is pursued as part of the *Ozone Alert!* program.

The City of Tulsa, Tulsa County, the Oklahoma Department of Transportation, and many local municipalities have banned the use of gasoline-powered lawn and garden equipment by their landscape crews on *Ozone Alert!* days. Since 1994, over 90 local lawn and garden companies and property management companies in the Tulsa area are

annually sent letters urging them to voluntarily limit mowing activities on *Ozone Alert!* days as well.

Remote Sensing Program. Funded by SUNOCO, INCOG conducted an infrared remote sensing program in 1994 to identify vehicles with high exhaust emissions and seek their voluntary repair. The infrared remote sensor is a device that shoots a beam of infrared light through the exhaust from a passing motor vehicle. An optical sensor is placed on the opposite side of the road to register how much of the light beam is absorbed by the gases. That reading can be converted into a measurement of pollutant levels (California Environmental Protection Agency, 1994).

The local remote sensing program enhanced the public's understanding of the air quality issues facing the Tulsa area. Although the program did not receive a high level of participation, it generated considerable media attention concerning the significance of vehicle exhaust emissions, especially high-emitters, in ozone formation. The program also raised awareness of the importance of proper vehicle maintenance to reduce exhaust emissions (internal INCOG report, 1995).

Metropolitan Tulsa Transit Authority (MTTA). MTTA actively supports the *Ozone Alert!* program and offers several options to local citizens to limit ozone pollution. On *Ozone Alert!* days, MTTA provides free bus rides to the public (through congestion mitigation-air quality or CMAQ funds). On the ten *Ozone Alert!* days in 1995, bus ridership increased an average of thirty-five percent (MTTA, personal communication, November 13, 1995). The "Jenks Jitney" and "Broken Arrow Express" are routes added by MTTA to encourage the use of public transportation by commuters living in area

suburbs. MTTA estimates that Express Route users reduced individual pollutant emissions by over seventy-five percent in 1995 (MTTA, personal communication, November 13, 1995). In another effort to reduce long-distance commutes into the Tulsa area, MTTA implemented a vanpool program in 1995.

Oklahoma Department of Transportation. The Oklahoma Department of Transportation (ODOT) announces upcoming *Ozone Alert!* days on variable message signs placed along heavily traveled local highways. In addition, ODOT suspends projects on *Ozone Alert!* days that may cause lane closures on local streets and highways to avoid excessive emissions due to vehicle idling.

The MERIT (Maximizing Emission Reductions by Intersource Trading) Program. In 1992, the MERIT (Maximizing Emission Reductions by Intersource Trading) program was developed by members of the INCOG Air Quality Committee to encourage early, innovative emission reductions by creating an economic incentive. MERIT banking and trading rules provide for accurate accounting of reduction credits and promote flexibility of compliance with present and future air quality regulations. To date, the MERIT program has not been implemented (internal INCOG report, 1995).

The Flexible Attainment Region Agreement

With the *Ozone Alert!* program in place since 1991, Tulsa sought a sort of "credit" from the EPA for taking proactive measures to reduce ozone pollution even though not mandated to do so. After many months of negotiations, federal, state, and local officials signed an agreement on August 22, 1995, designed to prevent Tulsa from being

redesignated a nonattainment area for the pollutant ozone. Working with the U.S. Conference of Mayors, Tulsa Mayor M. Susan Savage initiated discussions in early 1995 with Mary Nichols, Assistant Administrator of the EPA's Office of Air and Radiation, about Tulsa's air quality concerns (FAR Memorandum of Agreement, unpublished, 1995). After many negotiations, Tulsa was designated the nation's first "flexible attainment region" (FAR) to help the area avoid being designated a nonattainment area for the pollutant ozone.[3]

FAR marks a change in the EPA's "top-down" air pollution control policies set out by the Clean Air Act Amendments (CAAA) of 1977 and the subsequent CAAA of 1990. FAR allows local and state officials to tailor ozone control procedures specifically to Tulsa to avoid violation of the NAAQS. While such control measures are being assessed, Tulsa will maintain its federal attainment status for the criteria pollutant ozone.

FAR allows Tulsa to develop an ozone reduction strategy that reflects the local economy, meteorological conditions, geography, and transportation habits, instead of adopting a national program that may not fit the area's unique needs. An important part of FAR is the EPA's willingness to allow Tulsa to implement and evaluate the program before the city is penalized for violating the NAAQS for ozone.

Three main aspects of FAR include: the continued development and expansion of the *Ozone Alert!* program; the development of RESPONSE (Real Environmental Strategies for Partners in Ozone Negation Systems) measures, including revisions to the

[3] Signed in 1995, the flexible attainment region (FAR) agreement is to remain in effect for five years, unless the NAAQS for ozone is revised. Upon revision of the ozone standard, the agreement becomes null and void. Therefore, if revised standards are issued in July 1997, Tulsa must petition EPA for a new agreement or face possible nonattainment designation.

state implementation plan (SIP); and the creation of the Tulsa Ozone Prevention Strategy (TOPS) to examine the ozone formation process in the Tulsa area.

Ozone Alert! Program Expansion

As described previously in this chapter, Tulsa's *Ozone Alert!* program is a voluntary, episodic program created to maintain federal health-based air quality standards. The program, developed by the INCOG Air Quality Committee in 1991, consists of efforts from citizens, business and industry, state and local government, educators, and other facets of the Tulsa community.

As required by the FAR agreement, INCOG will continue to serve as the principal administrator of the *Ozone Alert!* program. INCOG will continue to implement all on-going program activities and supply funding for a program coordinator within the agency.

RESPONSE (Real Environmental Strategies for Partnerships in Ozone Negation Systems) Measures

The second goal of the FAR program is the development of RESPONSE measures, including items that require revisions to Oklahoma's state implementation plan (SIP) and those that do not require SIP revisions to be implemented. The SIP can be thought of as a "blue-print" describing the state's air pollution control strategies.

The "SIP RESPONSE" measures are mandatory and enforceable mechanisms to address the ozone problem in the Tulsa area. The "non-SIP RESPONSE" items do not require revisions to the SIP, therefore the measures are limited to those which can be

implemented on a voluntary basis and are not enforceable. The goal of these measures is to encourage public awareness and participation in ozone control strategies.

In the event of a violation of the NAAQS for ozone (three or more exceedances of the NAAQS of 0.124 ppm more than once per year in a three year period at a given monitoring station), a SIP revision mandating gasoline with a maximum RVP of 8.2 psi in the area and the introduction of legislation to include a "vehicle fuel system pressure test" in the current "Anti-Tampering Inspection Program" will be pursued. Beginning with this initial SIP revision, adequate time will be allowed for the SIP RESPONSE measures to be fully implemented and evaluated. Regardless of the number of exceedances or even violations of the ozone standard that occur while implementation and evaluation are taking place, the Tulsa area will not be designated an ozone nonattainment area.

"Non-SIP RESPONSE" measures do not require SIP revision to be implemented. The INCOG Air Quality Committee has created a priority list of items, each to be implemented within ten working days after each successive *exceedance* of the ozone standard. These "non-SIP RESPONSE" measures consist of the following items, listed in order of priority: 1) creating a "Smoking Vehicle Hotline;" 2) conducting public "Car Care Clinics;" 3) implementing a "Clean Fuels Fleets" program; 4) expanding "Employee Commute Options Awareness" programs for local businesses; and 5) creating an "Ozone Information Hotline."

Smoking Vehicle Hotline. The Smoking Vehicle Hotline program, patterned after a similar program in Texas, is designed to identify, report, and solicit repair of vehicles

with excessive exhaust emissions. The general public can report such vehicles by calling the hotline and leaving information about the smoking vehicles. The vehicle owner is sent a notification of the observation, and advice regarding vehicle repair. All aspects of the program are voluntary and nonenforceable, but it is hoped that the hotline will help generate public awareness of local air pollution problems. Implemented in 1996 after an exceedance of the ozone standard, the hotline is operated by the Oklahoma Department of Environmental Quality's Regional Office at Tulsa.

Car Care Clinics. Free public clinics are to be held to inform owners of their automobile emissions. Technicians test vehicles using a four-gas analyzer to determine the level of hydrocarbons and NOx present in the exhaust stream. As with the Smoking Vehicle Hotline, the goal of the clinics is to enhance public concern for air quality issues on a voluntary basis.

Clean Fuel Fleets. INCOG is beginning the application process to have the Tulsa area designated as a "Clean City" in the Department of Energy's *Clean Cities* program. The program works to form public and private partnerships in expanding the local alternative fuels infrastructure and encourage clean fuels fleet conversions. Alternative fuels recognized under the program include compressed natural gas (CNG), liquefied natural gas (LNG), liquefied petroleum gas (LPG or propane), ethanol, methanol, and electricity. Such alternative fuels have been shown to produce fewer ozone-forming emissions than gasoline and diesel (U.S. Department of Energy, 1995).

Employee Commute Options Awareness Programs. In an attempt to reduce employee vehicle miles traveled on *Ozone Alert!* days, an Employee Commute Options Awareness program, patterned after the programs unsuccessfully implemented in severe nonattainment areas, will be developed for employers with twenty-five or more employees in the Tulsa area. Essentially, this measure consists of strengthening the current "Local Businesses" facet of the *Ozone Alert!* program. For example, local businesses will be contacted more aggressively to participate in the program and the number of companies notified by fax of *Ozone Alert!* days will be increased.

Ozone Information Hotline. A hotline providing information to the public regarding ozone levels and actions to take on *Ozone Alert!* days will help increase awareness of local air pollution issues and control measures. This informational hotline may be incorporated into the Smoking Vehicle Hotline.

Tulsa Ozone Prevention Strategy

The Tulsa Ozone Prevention Strategy (TOPS) will attempt to develop and evaluate methods to more accurately identify sources of ozone pollution and predict its impact on the local area. Through TOPS, the effectiveness of air quality control methods developed under FAR can be evaluated.

TOPS consists of two parts. Part one calls for a revised and expanded emission inventory to be developed. This emissions inventory will follow the parameters of the EPA SIP inventory required of nonattainment areas. The emissions inventory is scheduled for completion in 1997. The Oklahoma Department of Environmental Quality

hired a local consulting firm to perform the inventory. The EPA provided a $50,000.00 grant to fund the emissions inventory update.

Part two describes the objectives of the creation of a model to more accurately predict the probability of exceeding the NAAQS for ozone in the Tulsa area. The model will include the correlation of past and present meteorological data with air quality measurements and examine the possibility of ozone precursor transport from other areas.

To develop the model, a review of the previous studies performed on Tulsa's air shed and comparison of these past studies with current scientific research in ozone formation is necessary. A local consulting group is currently performing this review and will offer suggestions as to the most effective scientific investigations to be performed in the Tulsa area. The study, funded by private funds donated to INCOG, is to be completed by mid-1997.

Marginal Nonattainment

If Tulsa had not been designated a flexible attainment region (FAR), three exceedances of the NAAQS for ozone at any local monitor in 1997 could cause the city to be designated a marginal nonattainment area, as defined in the Clean Air Act Amendments of 1990. Under the current regulations, Tulsa would be required to take the following actions as a marginal nonattainment area: 1) initially update the local emissions inventory; 2) periodically update the emissions inventory thereafter; 3) revise the state implementation plan (SIP) to tighten requirements on reasonably available control technology (RACT) and permit programs; and 4) offset VOC emissions (§ 182(a)).

Emissions Inventory

Within two years of nonattainment designation, the state is required to submit an updated local emissions inventory of VOCs, including stationary sources, mobile sources, and area sources. Every three year period thereafter, until attainment designation is granted, the state must update the emissions inventory (§ 182(a)(1)).

As mentioned previously, Tulsa will perform an emissions inventory as part of TOPS, to be completed in 1997. This does not, however, have to be submitted to the EPA unless nonattainment designation occurs. Therefore, Tulsa has flexibility in developing the emissions inventory since it does not require immediate submittal to the EPA.

SIP Revisions

The state must submit, within six months of nonattainment designation, a SIP revision that corrects and/or adds requirements to reasonably available control technology (RACT) for certain industries (§ 182(a)(2)). RACT refers to retrofit equipment specified by the EPA. Under the CAAA of 1990, each state, regardless of attainment status, specifies certain RACT requirements for large stationary sources in the SIP. A designation of marginal nonattainment would require the state to tighten RACT controls, perhaps by reevaluating the standard industrial code (SIC). The CAAA of 1990 do not, however, indicate specific ways by which state RACT controls must be strengthened. Increased RACT requirements could be very costly to some local businesses and industries.

Permits

Permits include information describing air pollutants being released by stationary sources, release limits, and the steps the source is taking to reduce pollution. Permit fees help fund stationary source emissions inventories conducted by the Oklahoma Department of Environmental Quality. As with RACT requirements, the EPA does not specify how a state must tighten permit controls.

Within two years after marginal nonattainment designation, the state must submit a SIP revision that includes provisions to require permits for construction and operation of each new or modified major stationary source to be located in the area. In addition, the state must also tighten controls on permit programs already in existence as part of the original SIP (§ 182(a)(2)(C)).

Emissions Offsets

According to the CAAA, a marginal nonattainment area's ratio of total emissions reductions of VOCs to total increased emissions of VOCs should be at least 1.1 to 1 tons (§182(a)(4)). As the severity of nonattainment status increases, this ratio increases.

Costs Associated with Nonattainment Status

In response to a request from Tulsa County Commissioner and Chair of the INCOG Air Quality Committee John Selph and Tulsa Mayor M. Susan Savage, the Tulsa City-County Health Department developed a report detailing the costs to Tulsa residents if the city were to be designated a nonattainment area for ozone (unpublished TCCHD

report, June 30, 1994). In the report, the Tulsa City-County Health Department estimated that the annual cost of conforming to the CAAA of 1990 mandates for marginal nonattainment areas would total nearly $5 million, or $6.90 per person, based a population of 710,000 residents. This total does not address the economic impact on business and industry in the area, however. New businesses may decide not to locate in an nonattainment area due to mandated pollution controls. Additionally, health care costs associated with nonattainment levels of ozone were not addressed by the report.

Flexible Attainment Versus Nonattainment

In comparing Tulsa's flexible attainment region (FAR) policy with what would be required if the area were to be classified as a marginal nonattainment area for ozone, several observations can be made. With FAR, ozone control policies are implemented on an incremental basis. For example, when Tulsa experiences a *violation* of the ozone standard, gasoline with 8.2 psi RVP and a fuel pressure test will be mandated. For every *exceedance* of the ozone standard Tulsa experiences, "non-SIP RESPONSE" measures, such as the creation of a "clean fuels fleets" program, will be implemented. If the region were designated a marginal nonattainment area, all measures required as part of the designation would be implemented concurrently.

By allowing for incremental implementation of ozone control measures, the effectiveness of the measures can be evaluated before the area is penalized for exceeding or even violating the NAAQS for ozone, normally resulting in nonattainment designation. It is planned that the provision in TOPS to develop a model of local ozone formation will

provide the mechanism for evaluating both the "SIP RESPONSE" and "non-SIP RESPONSE" measures.

In contrast, the Dallas/Ft. Worth area was designated a moderate nonattainment area for ozone in 1990.[4] In accordance with the CAAA of 1990, the area was required to implement certain pollution reduction measures by 1996. The area abided by those requirements yet experienced fifteen exceedances of the ozone standard in 1995 (Hayes, L., personal communication, February 11, 1997). Therefore, Dallas/Ft. Worth remains a nonattainment area for ozone.

Another major difference between FAR and nonattainment is FAR focuses on changing habits of the public rather than tightening pollution controls on already regulated industries as nonattainment designation requires. INCOG estimates that the majority of ozone precursors in the Tulsa area are emitted by mobile sources (Travis, G., personal communication, November 7, 1996). Therefore, imposing stricter controls on stationary sources, as required of nonattainment areas under the CAAA of 1990, may not be as effective as imposing tighter controls on automobiles and the driving habits of the public.

The Dallas/Ft. Worth area is beginning to incorporate programs that focus on changing the habits of the public as part of their ozone reduction strategies. As mentioned previously, although Dallas/Ft. Worth has met all requirements under the CAAA of 1990, the area continues to exceed the NAAQS for ozone. Therefore, the area has adopted a program patterned after Tulsa's *Ozone Alert!* program and a smoking

[4] Under the Clean Air Act Amendments of 1990, EPA designated the Texas counties of Dallas, Denton, Collin, and Tarrant as moderate nonattainment areas for the pollutant ozone.

vehicle hotline to reduce ozone pollution through public actions. As in Tulsa, the voluntary ozone reduction program in Dallas/Ft. Worth consists of voluntary public and school education campaigns, an employers' program, and programs designed to increase the use of public transportation and carpools (Dallas/Ft. Worth "Ozone Action" brochure, 1996).

A designation of nonattainment generally deters both industrial and commercial expansion into such areas due to the expense of additional pollution control devices, stronger permit requirements, and the threat of economic sanctions. FAR puts the majority of responsibility for ozone pollution control measures on the public by emphasizing voluntary, episodic, public awareness programs. The RESPONSE measures such as the "employee commute options awareness" program ask for a voluntary commitment by business and industry on a few days during the summer rather than mandating their year-long participation in pollution reduction.

Conclusion

To maintain Tulsa's attainment status for the pollutant ozone, the INCOG Air Quality Committee--a partnership among local governments, business, industry, health groups, and environmental organizations--developed the *Ozone Alert!* program in 1991. This program consists of voluntary efforts on an "as needed" basis by local governments, business and industry, and citizens to improve local air quality. In spite of the pollution reduction measures implemented under the *Ozone Alert!* program, Tulsa has experienced seven exceedances of the ozone standard since June 1991. In fact, the area could be

redesignated a marginal nonattainment area for ozone if the standard is exceeded three times in 1997 at any of the three local ozone monitoring stations.

The *Ozone Alert!* program relies on the accurate prediction of the onset of meteorological conditions favorable to the formation of high ozone concentrations, at least one day in advance. This allows sufficient lead time for the publicity campaign aspect of the program. The Tulsa City-County Health Department in collaboration with the National Weather Service, developed a meteorological model to predict days when high ozone levels could potentially occur.

Since the program's creation in 1991, many public and private entities in Tulsa have identified and implemented voluntary initiatives to improve air quality as part of the *Ozone Alert!* program. The *Ozone Alert!* program is administered by the Indian Nations Council of Governments (INCOG), in cooperation with the City of Tulsa, Tulsa County, the ODEQ-ROAT, and other entities.

On *Ozone Alert!* days, the public is urged to limit driving, mowing, and refueling. Program administrators believe this voluntary, episodic approach to ozone pollution control is more readily accepted by the public than mandated, long term actions. The *Ozone Alert!* program consists of voluntary efforts by public and private entities, including gasoline suppliers and retailers, local businesses, schools, the Metropolitan Tulsa Transit Authority, and the Oklahoma Department of Transportation.

With the *Ozone Alert!* program in place since 1991, Tulsa sought a sort of "credit" from the EPA for taking proactive measures to reduce ozone pollution even though not mandated to do so. After many months of negotiations, federal, state, and local officials

signed the flexible attainment region agreement in 1995, designed to prevent Tulsa from being redesignated a nonattainment area for the pollutant ozone.

Three main aspects of FAR include: the continued development and expansion of the *Ozone Alert!* program; the development of RESPONSE (Real Environmental Strategies for Partners in Ozone Negation Systems) measures, including revisions to the state implementation plan (SIP); and the creation of the Tulsa Ozone Prevention Strategy (TOPS) to examine the ozone formation process in the Tulsa area.

FAR allows Tulsa to develop an ozone reduction strategy that reflects the local economy, meteorological conditions, geography, and transportation habits, instead of adopting a national program that may not fit the area's unique needs. An important part of FAR is the EPA's willingness to allow Tulsa to implement the program incrementally and evaluate its success before the city is penalized for violating the NAAQS for ozone.

CHAPTER V

FINDINGS: TULSA'S *OZONE ALERT!* PROGRAM-- A POLLUTION SOLUTION?

Although the *Ozone Alert!* program is designed to reduce air pollution in Tulsa, Oklahoma, thereby maintaining attainment status, the area continues to exceed the national ambient air quality standards (NAAQS) for ozone. The following offers recommendations for improving Tulsa's air quality programs, based on the performance of a comparative analysis of Tulsa's *Ozone Alert!* program and other voluntary ozone reduction programs throughout the country.

Lack of Funding

Under the Intermodal Surface Transportation Efficiency Act of 1991 (Pub. L. 102-240, Dec. 18, 1991, 105 Stat. 1914), states are eligible to receive Congestion Mitigation-Air Quality (CMAQ) funds to support projects designed to reduce air pollution (U.S. Department of Transportation, 1994). CMAQ funds can be used to improve public transportation, expand ridesharing programs, construct pedestrian and bicycling facilities, and facilitate other air quality programs. Nonattainment areas are eligible for the majority of CMAQ funds, while attainment areas receive very little funding.

At first glance, the distribution of the majority of CMAQ funds to areas that are not in compliance with NAAQS makes sense. After all, these are the areas where air pollution reduction strategies are needed most. The CMAQ distribution method,

however, gives little incentive for attainment areas, such as Tulsa, to implement programs to reduce air pollution before it becomes a problem.

Tulsa's *Ozone Alert!* program is operated from a small budget, funded by CMAQ funds, INCOG, and occasional contribution by private entities (Pinc, G., personal communication, December 11, 1996). While the program includes many public awareness activities, lack of funding limits a large scale effort. The *Ozone Alert!* program relies primarily on the voluntary efforts of the members of the INCOG Air Quality Committee to implement the various facets of the program. In nonattainment cities such as Dallas/Ft. Worth, however, adequate CMAQ funding exists to hire public relations firms to produce eye-catching advertising campaigns to promote ozone awareness.

Non-Quantifiable

Another problem facing Tulsa's *Ozone Alert!* program is that due to its voluntary nature, the measures taken under the program are not easily quantified. Without a method to determine the amount of emissions reductions stemming from the program, it is difficult to measure the effectiveness of each facet of the program.

On *Ozone Alert!* days from 1992-1996, the Metropolitan Tulsa Transit Authority (MTTA) offered free bus rides. MTTA reports an average increase in ridership on such days of thirty-seven percent (MTTA, personal communication November 13, 1995). This increase, however, is highly uncertain and should not be used as a true indicator of the *Ozone Alert!* program's effectiveness in reducing emissions. For instance, ridership increases are based on bus driver observations since no revenue is collected on *Ozone*

Alert! days. The amount of revenue generated each day is the normal procedure by which MTTA determines ridership. Additionally, MTTA reports that many daycare centers take advantage of the free bus fares on *Ozone Alert!* days to take students on field trips (Travis, G., personal communication, January 17, 1996). Finally, MTTA admits that many homeless people ride the bus on *Ozone Alert!* days as an air-conditioned break from Oklahoma's summer heat (Travis, G., personal communication, January 17, 1996).

Difficulty in quantifying the effectiveness of voluntary ozone reduction programs is not unique to Tulsa: other cities with similar programs experience the same difficulty. Some cities are taking steps to measure public participation in and knowledge of their voluntary ozone reduction programs. For example, Kansas City hired a local market research firm in 1994 to create and perform a survey to measure the level of public awareness of Kansas City's *Heartland Sky* voluntary ozone reduction program (unpublished report, Mid-America Regional Council [MARC], 1996). The objectives of the study included the following: to reveal the general public's attitudes about air quality; to identify current and potential means of providing air quality information to the public; and to identify the public's willingness to take voluntary actions to reduce ozone (unpublished report, MARC). A random sample of 600 Kansas City residents participated in the survey. The survey found that although two-thirds of those questioned were concerned about air quality and willing to take voluntary efforts to reduce ozone, only one-sixth of the respondents were aware of the *Heartland Sky* program. This information served to strengthen Kansas City's efforts to inform the public of the local ozone control program. Although the survey did not quantify the amount of emissions reductions realized through Kansas City's voluntary program, administrators were

encouraged by the public's professed willingness to perform voluntary ozone reduction measures.

To date, a survey similar to that performed in Kansas City has not been undertaken in Tulsa. In March 1995, however, INCOG sent an *Ozone Alert!* information packet to 1399 local businesses with greater than ten employees, registered with the Metropolitan Tulsa Chamber of Commerce. The packet included an "*Ozone Alert!* Employer Participation Survey and Fax Notification" form. The businesses were to return the form so INCOG could gain a better insight into the level of participation in the program. Of the 1399 forms mailed, only eighty-five were returned. Of the eighty-five respondents, twenty-nine had participated in the *Ozone Alert!* program in 1994. The remaining fifty-six had not participated in 1994, but desired to participate in 1995. All eighty-five businesses that returned the surveys desired to be included in the *Ozone Alert!* fax notification system. Additionally, over eight percent of the responding companies said they would encourage their employees to seek alternate means of transportation on *Ozone Alert!* days and encourage their employees not to drive to lunch on such days. Of the eighty-five that returned the survey, only twelve businesses had not heard of the *Ozone Alert!* program before the mailing. Since only eighty-five of the 1399 sent surveys responded, it is difficult to determine the familiarity of local businesses with the *Ozone Alert!* program based on the results.

In July 1995, another survey was sent to 150 local businesses and organizations participating the *Ozone Alert!* fax notification system to determine their level of participation in the program. Forty-two companies responded to the survey. Nearly sixty percent of the respondents indicated that they alter work schedules on *Ozone Alert!* days.

Eighty-three percent of the companies and organizations responding to the survey encourage employees to participate in carpools/vanpools or use public transportation on *Ozone Alert!* days. Only six of the responding companies (fourteen percent) offer subsidies or preferential parking to carpoolers/vanpoolers. Fifty-seven percent of the respondents encourage their employees not to drive to lunch on *Ozone Alert!* days and four companies cater staff lunches on such days. Seventy-three percent of the companies provide *Ozone Alert!* information through internal publications. Only six companies in 1995 notified employees of upcoming *Ozone Alert!* days through e-mail. Finally, forty-three percent of the responding companies indicated that they perform "other" actions on *Ozone Alert!* days. Respondents indicated anywhere from six to 1400 employees participating in the *Ozone Alert!* program at their company or organization. With only one-third of those surveyed responding, only a thumb-nail sketch of local companies effort could be ascertained from the survey.

Lack of a Long Range Plan

Although Tulsa has implemented the *Ozone Alert!* program since 1991, exceedances of the ozone standard continue to occur. While Tulsa may not necessarily be penalized for the exceedances in the form of a nonattainment designation due to the flexible attainment region (FAR) agreement with the EPA, public health can be adversely affected with each exceedance of the ozone standard. The *Ozone Alert!* program and FAR measures are only short term solutions. These measures address ozone on an "as needed" basis. Ultimately, a long term solution must be found to curb the air pollution problem in Tulsa.

One long term change that should be made is the reduction of the dependence on the automobile. In the Tulsa area, seventy percent of ozone-forming emissions stem from mobile sources, most notably gasoline and diesel-powered automobiles (Travis, G., personal communication, November 7, 1996). The alternative to the use of cars range from increased use of public transportation and the use of alternative fuels, to zoning practices that do not encourage urban sprawl. Such measures, however, encounter funding difficulty and genuine public resistance, as illustrated by Perkins: "the love affair between man and car is a serious one, not easily broken up on matter how hard the parent may try" (1974, p. 14).

According to an INCOG report, each individual riding a diesel-powered bus to work instead of driving a single occupancy vehicle reduces hydrocarbon emissions by 9.1 pounds per year, carbon monoxide emissions by 62.5 pounds per year, and nitrogen oxide emissions by 4.9 pounds per year (unpublished report using MOBILE 5A, 1995). Emissions reductions are greater if the transit system offers compressed natural gas or electric buses. Transit is not a popular commuter option in Tulsa, however.

To make public transportation more appealing, the system should be expanded to serve a greater area, especially the outlying suburbs, from which numerous individuals commute to work each day. MTTA's budget cannot support an upgrade at this time, however.

Light rail is another option to encourage people to cease commuting in single occupancy vehicles. The Dallas/Ft. Worth area opened the electric-powered "DART (Dallas Area Rapid Transit) Rail" system in 1996 (Goldberg, 1996). The San Francisco Bay Area Rapid Transit District (BART) has operated light rail service throughout

California's Bay Area since 1995 ("Bart Celebrates," 1997). Other cities are also exploring the implementation of light rail systems. Again, these systems are too expensive for Tulsa to implement at this time. Since Dallas/Ft. Worth and San Francisco are nonattainment areas for ozone and must meet mandatory emissions reductions, these areas receive ample federal funding, such as CMAQ funds, to support transit expansions and the construction of light rail systems.

Another method of reducing mobile emissions is through the use of alternative fuels. The Clean Air Act Amendments of 1990 (CAAA) address "clean fuel fleets" in Title II. The twenty-two worst ozone and carbon monoxide nonattainment areas are mandated to acquire certain percentages of alternative fuel vehicles (or use reformulated gasoline) in their efforts to reduce urban air pollution. The Energy Policy Act of 1992 (EPACT) also sets mandates for the acquisition of alternative fuel vehicles (AFVs) by both public and private fleets in an attempt to reduce oil imports and improve air quality. In Tulsa, a voluntary *Clean Cities* program is conducted to encourage the use of alternative fuels vehicles, thereby reducing ozone forming emissions. *Clean Cities* is a voluntary federal program designed to accelerate and expand the use of alternative fuel vehicles in communities throughout the country and provide refueling and maintenance facilities for their operation. Sponsored by the U.S. Department of Energy (DOE), *Clean Cities* encourages local governments and private companies to form partnerships in developing markets for AFVs.

Fuels recognized as "alternative fuels" include compressed natural gas (CNG), liquefied natural gas (LNG), liquefied petroleum gas (LPG or propane), biodiesel, 100%

ethanol, 5% ethanol mixed with 15% reformulated gasoline (E85), 100% methanol, 85% methanol mixed with 15% reformulated gasoline (M85), hydrogen, and electricity.

Propane and CNG are the two most commonly used alternative fuels in Oklahoma. These fuels are advantageous in that they are domestically produced and very abundant and less expensive than gasoline in Oklahoma. These fuels also have lower carbon monoxide (CO), hydrocarbon (HC), and nitrogen oxide (NOx) emissions than traditional gasoline. The disadvantages of using propane and CNG as automotive fuels are that their range is less than gasoline and costly modifications must be made to vehicles in order to run on such fuels. In addition, the refueling infrastructure for CNG and propane (and other alternative fuels) is not developed to an extent where such fuels can rival the convenience of gasoline or diesel.

Although Oklahoma offers tax incentives and zero interest loan funds for the conversion of vehicles to alternative fuels, very few individuals take advantage of the programs. Most people do not want to sacrifice the convenience of their traditional vehicle, even if they could save money and reduce air pollution in the long run.

Due to the public's demonstrated resistance to using alternative means of transportation and the nearly exponential growth in vehicle miles traveled (VMT), future zoning practices must reduce urban sprawl. Since 1955, the number of people residing in downtown Los Angeles has only increased by five percent, yet the number of cars entering downtown has increased by twenty-three percent due to commuting (Woodhull, 1991). In Tulsa, VMT will increase by thirty-nine percent by the year 2010, while population will only increase by thirteen percent (INCOG, 1996). In order to reduce the

public's dependence on the automobile, thereby reducing emissions, current urban planning methods must be reevaluated.

By locating neighborhoods, schools, and commercial and business districts within relatively short distances from one another, less automobile travel will be necessary. Coupled with the dedication of bicycle lanes and an increase in sidewalks, alternatives to automobile transportation can be fostered. Several cities are using such "traffic calming" methods to reduce the use of automobiles and encourage pedestrian and bicycle travel (Citizens Advocating Responsible Transportation, 1999; Hoyle, 1995). For example, Singapore taxes motorists that drive personal vehicles into downtown instead of using public transportation (Wright et. al, 1996).

Many cities, including Tulsa, are allocating funds to downtown renewal projects. Such projects may provide the opportunity to locate schools, stores, and workplaces all within walking or biking distance, thereby decreasing long range commutes and air pollution.

While local planners and lawmakers have long recognized the need for long range plans in the areas of transportation and urban development, no long range strategy currently exists for controlling Tulsa's air pollution problem. Tulsa operates the *Ozone Alert!* program on an episodic, "as needed" basis throughout the summer months. Cities in Texas, however, have realized that effective air pollution control takes more than an episodic effort.

Clean Texas 2000

An example of a long range plan for air quality control is found in Texas. In 1992, the Texas Natural Resource Conservation Commission (TNRCC) established the "Clean Texas 2000" program (TNRCC, 1995). The program relies on the voluntary, cooperative efforts of various Texas communities, governmental organizations, representatives of business and industry, and individual citizens to reduce pollution to land, air, and water. The goals of "Clean Texas 2000" include the following: reduce hazardous waste and toxic emissions by fifty percent by the year 2000; reduce the amount of solid waste entering Texas landfills by fifty percent by the year 2000; significantly reduce pollution entering Texas waterways; meet or exceed federal air quality standards; and educate all Texans on environmental improvement and protection (TNRCC).

Since 1992, the public education aspect of the program has reached eighty percent of Texas residents through the use of billboards, radio advertisements, and various free publications (TNRCC). The TNRCC also developed a toll-free information hotline that provides environmental tips and free literature.

Another aspect of the program targets industrial sources. "Clean Industries 2000" is a voluntary program for industries that agree to reduce pollution levels beyond state and federal requirements. One hundred fourteen of Texas' largest facilities are involved in the program (TNRCC, 1995). Membership requires at least a fifty percent reduction in hazardous waste and/or toxic releases by the year 2000 from 1987 levels, an internal review system to ensure compliance with environmental regulations, the formation of a public communication program, and sponsorship of a community environmental project.

The "Clean Industries 2000" program consists of Permanent Pollution Prevent Programs (P4), "Site Assistance Visit" (SAV) programs, and pollution prevention workshops.

Permanent Pollution Prevent Programs (P4) are designed to approach pollution prevention with industry on a regional basis. Through the Texas Natural Resource Conservation Commission, P4 provides industrial facilities with technical assistance to implement permanent pollution prevention programs. The goal of the program is to build industry and governmental cooperation and assist facilities in developing environmental partnerships.

The Texas Office of Pollution Prevention and Reduction (OPPR) conducts the free, non-regulatory, voluntary "Site Assistance Visit" (SAV) program. OPPR engineers and scientists visit industrial facilities to assist with pollution prevention efforts. SAV program goals are to reduce pollution and costs and generate innovative pollution prevention ideas. To date, over forty facilities have been visited as part of the SAV program, reportedly resulting in the implementation of projects saving millions of dollars and reducing millions of pounds of hazardous and toxic wastes (TNRCC, 1995).

"Clean Texas 2000" also includes programs to inform small businesses of regulations affecting them under the Clean Air Act Amendments of 1990. The "Small Business Technical Assistance" program was established to educate small business owners on environmental regulations and provide technical assistance in complying with such regulations.

As part of Texas' state implementation plan (SIP) for the state's four major ozone nonattainment areas, the Texas Natural Resource Conservation Commission (TNRCC) adopted statewide rules for small gasoline-powered engines and consumer and commercial

products. The small gasoline-powered engine rule requires lower emission rates from lawn mowers, weedeaters, lawn tractors, chainsaws, and other engines smaller than twenty-five horsepower and manufactured after January 1995 (TNRCC, 1995). Small gasoline-powered engines are not subject to federal emission limits and therefore emit high levels of air pollutants. The consumer and commercial products rule will require lower volatile organic compound (VOC) content in various products used in or around the home such as deodorants, cosmetics, cleaners, charcoal lighter fluid, windshield washer fluid, and insecticides (TNRCC). VOCs are key components in ozone formation.

Texas' long range plan for air pollution reduction consists of mandates and increased voluntary programs. Local agencies make a concerted effort to inform the public and businesses and industries of pollution prevention practices in a non-threatening, informational manner. Realizing that federal mandates alone may not be enough to bring areas into attainment (as in the case of Dallas/Ft. Worth), Texas is setting local mandates and improving voluntary programs in an effort to reduce the state's air pollution.

Ozone Alert! Tulsa's Pollution Solution?

While the *Ozone Alert!* program and the measures implemented as part of the flexible attainment region are a step in the right direction of regulating Tulsa's air pollution, these are not long term solutions. Ultimately, a long range plan must be devised to ensure continued compliance with health-based ozone standards. Measures such as increased public transportation, the use of alternative fuels, and better zoning practices are needed to reduce the ever increasing use of the automobile. While automobile emissions standards are continually tightened, the air quality benefits realized through stricter

realized through stricter standards are weakened due to the fact that Americans are driving more miles each year. Therefore, long term strategies to reduce the use of automobiles need to be developed in order to permanently reduce local air pollution.

The Indian Nations Council of Governments should facilitate the development of a long range plan for ozone control in metropolitan Tulsa. The INCOG Air Quality, the Tulsa Area *Clean Cities* Coalition, staff transportation planners, and urban planning staff members should work together to facilitate local programs that encourage long term air pollution reduction. The upgrade of public transportation, increased use of alternative fuels by City of the Tulsa, Tulsa County, and the Metropolitan Tulsa Transit Authority fleets, and zoning practices to discourage urban sprawl should all be addressed in the plan. The "Tulsa Project" downtown renovation plan could showcase the city's efforts in long range air quality planning by integrating electric-powered shuttle buses, park and ride lots to discourage congestion, and commercial and residential areas all within walking distance.

Local lawmakers could take initiatives to maintain the area's attainment status for ozone by passing local pollution control ordinances, as well. For example, small gasoline-powered engines and consumer and commercial products could be regulated locally, mirroring similar legislation implemented in Texas in 1995.

Recommendations for Future Studies

INCOG should perform a follow-up survey to local companies to determine if participation in and/or knowledge of the *Ozone Alert!* program has increased INCOG should again acquire a mailing list from the Metropolitan Tulsa Chamber of Commerce

and send additional *Ozone Alert!* information along with the survey. To measure public participation and awareness of the *Ozone Alert!* program, INCOG should survey the public about the *Ozone Alert!* program. Kansas City's survey was funded through an EPA Pollution Prevention grant. If INCOG cannot procure such a grant, perhaps a graduate student or intern could help air quality staff members develop and perform a survey. As INCOG serves as an official affiliate of U.S. Census Bureau, and employs trained statisticians, a properly executed survey with adequate demographic representation could be created in-house.

Since the majority of Tulsa's ozone-forming emissions stem from mobile sources, a study to determine the difference between traffic counts on *Ozone Alert!* days versus non-*Ozone Alert!* days would be an effective means to measure local participation in efforts to reduce automobile travel on such days. Currently, the Oklahoma Department of Transportation maintains one automatic traffic recorder (ATR) on U.S. 244 in Tulsa, near the Sheridan exit (Oklahoma Department of Transportation, 1996). ATRs measure traffic continuously in each lane of traffic. Additionally, the ATR determines whether the traffic is from vehicles with one, two, or three or more axles. For example, vehicles with one axel include motorcycles; vehicles with two axles include standard light-duty cars and trucks; and vehicles with three or more axles include larger vehicles such as commercial trucks and trailers. If several ATRs were placed on major highways and expressways throughout the city during the ozone season (May through September), the traffic levels on *Ozone Alert!* days versus non-*Ozone Alert!* days could be determined. If no difference is found, a major goal of the *Ozone Alert!* program--emissions reductions--is not being realized. The information gained from the traffic study, coupled with public and business

surveys, could be used to help quantify the effect of the voluntary program.

In an effort to determine the cause of Tulsa's ozone problem, the state of Oklahoma should join a research group such as the North American Research Strategy for Tropospheric Ozone (NARSTO). Perhaps the knowledge gained from membership in such an alliance could be used in the local Tulsa Ozone Prevention Strategy (TOPS).

CHAPTER VI

SUMMARY AND CONCLUSIONS

Throughout the 1980s, Tulsa, Oklahoma did not meet federal health-based standards for the pollutant ozone. After successfully preventing the violation of federal ozone limits for the previous three years, the area was designated an attainment area for the criteria pollutant ozone in 1990. Tulsa experienced an exceedance of the federal ozone standard on June 24, 1991, however. As a result, the INCOG (Indian Nations Council of Governments) Air Quality Committee developed and implemented the *Ozone Alert!* program. The program relies on voluntary efforts by local governments, business and industry, and citizens to reduce air pollution on days when meteorological conditions exist that are conducive to forming high levels of ozone.

On *Ozone Alert!* days, the public is urged to limit driving, mowing, and refueling. Nearly 400 businesses in the Tulsa area receive advance notice of *Ozone Alert!* days through a fax system. Local government agencies refrain from operating lawn and garden equipment on *Ozone Alert!* days. Since 1992, local gasoline suppliers have voluntarily distributed gas producing fewer evaporative emissions during the ozone season, May through September.

Local employers also participate in the *Ozone Alert!* program. Tulsa area businesses have created *Ozone Alert!* programs within their companies to encourage their employees to participate in air pollution reduction activities. For example, some local companies award car-poolers with "prime" parking places, t-shirts and movie passes.

Others create special editions of company newsletters to inform employees about ozone and actions they can take to prevent the formation of the pollutant.

School children throughout Tulsa County participate in annual ozone awareness poster contests. Teachers have access to ozone curricula and an informational video, both developed by INCOG, in faculty resource libraries to assist in ozone educational efforts.

In spite of the voluntary pollution reduction measures implemented under the *Ozone Alert!* program and industrial mandates under the Clean Air Act, Tulsa continues to exceed federal ozone limits. If voluntary efforts fail to reduce local ozone levels, Tulsa could face strict and costly pollution control measures. An area that is not in compliance with federal air quality standards may experience a decrease in economic development and growth. For example, businesses and industries may choose not to locate in the area, as they may be mandated to install costly pollution prevention equipment and programs. Citizens may choose not to reside in areas with high ozone levels due to health risks.

The preceding case study offers possible strategies to strengthen the area's air pollution abatement activities. The author's findings are a result of performing a comparative analysis Tulsa's *Ozone Alert!* program and other voluntary ozone reduction programs throughout the country.

The case study concludes that while the *Ozone Alert!* program and other local air pollution control measures may regulate Tulsa's air pollution temporarily, these are not long term solutions. Ultimately, a long range plan must be devised to ensure continued compliance with health-based ozone standards. Measures such as increased public transportation, the use of alternative fuels, and better zoning practices are needed to reduce the ever increasing use of the automobile.

Plans similar to "Clean Texas 2000" and public participation surveys such as performed in Kansas City are measures the Tulsa area needs to implement to strengthen the current ozone control methods. Studies should also be performed to grasp a firmer understanding of the local meteorological, geographical, and chemical make-up of ozone, so more effective means of controlling the pollutant can be implemented in the future.

While the debate rages as to who should pay for the control of ozone and the extent of the adverse health effects the pollutant presents, the air continues to be breathed and used by all individuals, animals, and plants. Ultimately, everyone pays for poor air quality: economically, aesthetically, and physically. And ultimately, everyone must work together to control air pollution.

REFERENCES

After 10-Year Smog Alert, Bush Signs Clean-Air Law. (1990). Palm Beach Post (Vol. 5, Article 19). Boca Raton, FL: Social Issues Resources.

American Lung Association. (1995). Danger Zones: Ozone Air Pollution and Our Children. New York: American Lung Association.

BART Celebrates Opening of 14-Mile Rapid Rail Line. (1997, May). Passenger Transport, 55 (20), 1, 8-9.

Bates, D.V., & Sizto, R. (1986). A Study of Hospital Admissions and Air Pollutants in Southern Ontario: The Acid Summer Haze Effect. Environmental Research, 43, 317-31.

Beck, C. (1997, March). Leave Well Enough Alone. EM Magazine, p. 30.

Brewer, R. (1988). The Science of Ecology. Philadelphia: W.B. Saunders Company.

Burnett, R.T., Dales, R.E., Raizenne, D.K., Summers, P.W., Roberts, G.R., Raad-Young, M., Dann, T., & Brook, J. (1994). Effects of Low Ambient Levels of Ozone and Sulfates on the Frequency of Respiratory Admissions to Ontario Hospitals. Environmental Research, 65, 172-194.

Business Study Urges EPA to Retain Ozone Reg at .12 ppm. (1992, October 12). Air Water Pollution Report, p. 40-3.

Cable, S. & Cable, C. (1995). Environmental Problems Grassroots Solutions. New York: St. Martin's Press.

California Environmental Protection Agency. (1994). On-Road Remote Sensing of CO and HC Emissions in California. CA: California Environmental Protection Agency.

Chameides, W.L. & Cowling, E.B. (1995). The State of the Southern Oxidants Study (SOS): Policy-Relevant Findings in Ozone Pollution Research 1988 - 1994. Raleigh, NC: College of Forest Resources, North Caroline State University.

Citizens Advocating Responsible Transportation. (1989). Traffic Calming: The Solution to Urban Traffic and a New Vision for Neighborhood Livability. Ashgrove, Q, Australia: Citizens Advocating Responsible Transportation.

Clark, J. (1996, November). Proposals on Ozone and Particulate Matter NAAQS. Presented at the APTI Workshop T-034-96, North Carolina State University, Raleigh, NC.

Clean Air Act (as amended) PL 101-549, 104 Stat. 2399, 1990.

Cody, R.P., Weisel, C.P., Birnbaum, G., & Lioy, P.J. (1992). The Effect of Ozone Associated with Summertime Photochemical Smog on the Frequency of Asthma Visits to Hospital Emergency Departments. Environmental Research, 58, 184-194.

Cooper, C.D., & Alley, F.C. (1994). Air Pollution Control: A Design Approach. (3rd ed.). Prospect Heights , IL: Waveland Press.

Corn, D. (1997, March 24). A Bad Air Day. The Nation, pp. 16-20.

Cropper, M.L., & Oates, W.E. (1992). Environmental Economics: A Survey. Journal of Economic Literature, 30, 675-740.

EPA Says it Will Not Enforce ECO Requirement. (1995, January 27). Mobile Source Report, p. 1.

Fiorino, D.J. (1989). Environmental Risk and Democratic Process: A Critical Review Columbia Journal of Environmental Law, 14, 501-47.

Ford, B. (1997, January 3). New Laws Take Effect This Year. Tulsa World, p. A9.

Goldberg, R. (1996, December). Rail Transit Continues to Climb. Passenger Transport, 54 (51), 5, 11.

Green, M.C., & Gebhart, K.A. (1997). Clean Air Corridors: A Geographic and Meteorologic Characterization. Journal of Air & Waste Management, 47, 403-10.

Hattis, D., & Kennedy, D. (1986). Assessing Risks from Health Hazards: An Imperfect Science. Technology Review, 89 (4), 60-71.

Hill, J.W., & Kolb, D.K. (1995). Chemistry for Changing Times. (7th ed.). Upper Saddle River, NJ: Prentice Hall.

Hoban, T.M., & Brooks, R.O. (1987). Green Justice: The Environment and the Courts. Boulder, CO: Westview Press.

Hoyle, C.L. (1995). Traffic Calming. Chicago: American Planning Association.

Hunton & Williams. (1993). Clean Air Handbook. (2nd ed.). Rockville, MD: Government Institutes.

Indian Nations Council of Governments. (1996). 2020 Foresight: The Long Range Transportation Plan. Tulsa, OK: Indian Nations Council of Governments.

Lowe, M.D. (1990). Alternatives to Automobiles: Transport for Livable Cities. Worldwatch, 98. Washington, DC: Worldwatch Institute.

Marchant, G.E., & Danzeisen, D.P. (1989). "Acceptable" Risk for Hazardous Air Pollutants. Harvard Environmental Law Review, 13, 535-58.

Michaels, R. (1996). Health Risks Support One-Hour Airborne Particle Standard with Data Acquisition Via Rapid Automated Monitoring Instrumentation. Proceedings of the 21st conference of the National Association of Environmental Professionals. Houston, TX.

Myers, J. (1996, September 27). Ozone Standard Opposed. Tulsa World, p. A1.

Myers, J. (1996, December 5). Clean Air Post Goes to Inhofe. Tulsa World, p. A1.

National Association of Counties Research Foundation. (1966). Community Action Program for Air Pollution Control. Washington, DC: National Association of Counties Research Foundation.

Oklahoma Department of Transportation. (1996). Oklahoma Traffic Characteristics Report: 1995. Oklahoma City, OK: Oklahoma Department of Transportation.

Ostro, B., Lipsett, M., Mann, J., Krupnick, A., & Harrington, W. (1993). Air Pollution and Respiratory Morbidity Among Adults in Southern California. American Journal of Epidemiology 137, (7), 691-700.

Perkins, H.C. (1974). Air Pollution. New York: McGraw Hill.

Pribitkin, A.E. (1993). The Need for a Revision of Ozone Standards: Why Has the EPA Failed to Respond? Temple Environmental Law & Technology Journal, 13, 103-121.

Public Health Service. (1967). Air Pollution Engineering Manual. Washington, DC: U.S. Government Printing Office.

Richards, W., Azen, S., Weiss, J., Stocking, S., & Church, J. (1981). Los Angeles Air Pollution and Asthma in Children. Ann. Allergy, 47, 348-54.

Schmitzberger, R., Rhomberg, K., Buchele, H., Puchegger, R., Schmitzberger-Natzmer, D., Kemmler, G., & Panosch, B. (1993). Effects of Air Pollution on the Respiratory Tract of Children. Pediatric Pulmonology, 15 (2), 68-74.

Schwartz, M. (1993). The Environment and the Law. New York: Chelsea House.

Skinner, B.J., & Porter, S.C. (1992). The Dynamic Earth. (2nd ed.). New York: John Wiley & Sons.

Smith, Z.A. (1995). The Environmental Policy Paradox. (2nd ed.). Englewood Cliffs, CO: Prentice Hall.

State and Territorial Air Pollution Program Administrators & Association of Local Air Pollution Control Officials. (1993). Meeting the 15-Percent Rate-of-Progress Requirement Under the Clean Air Act: A Menu of Options. Washington, D.C.: State and Territorial Air Pollution Program Administrator & Association of Local Air Pollution Control Officials.

Te Brake, W.H. (1975). Air Pollution and Fuel Crisis in Preindustrial London, 1250-1650. Technology and Culture, 16 (3), 619-28.

Texas Natural Resource Conservation Commission. (1995). Clean Texas 2000. Austin, TX: Texas Natural Resource Conservation Commission.

Travis, C.C., & Hattemer-Frey, H.A. (1988). Determining an Acceptable Level of Risk. Environmental Science and Technology, 22, 873-6.

Underwood, L. (1996). Airborne Menace. Free China Review (Vol. 6, Article 37). Boca Raton, FL: Social Issues Resources.

U.S. Department of Energy. (1995). Taking an Alternative Route. Washington, DC: U.S. Government Printing Office.

U.S. Department of Transportation. (1994). A Guide to the Congestion Mitigation and Air Quality Improvement Program. Washington, DC: U.S. Government Printing Office.

U.S. Department of Transportation. (1996). Transportation Air Quality: Selected Facts and Figures. Washington, DC: U.S. Government Printing Office.

U.S. Environmental Protection Agency. (1993). The Plain English Guide to the Clean Air Act. Washington, DC: U.S. Government Printing Office.

U.S. Environmental Protection Agency. (1994). National Water Quality Inventory: 1994 Report to Congress. Washington, DC: U.S. Government Printing Office.

U.S. Environmental Protection Agency. (1996). Municipal Solid Waste Characterization Report - 1996 Edition. Washington, DC: U.S. Government Printing Office.

U.S. Environmental Protection Agency. (1996). National Air Quality and Emissions Trends Report, 1995. Washington, DC: U.S. Government Printing Office.

U.S. Environmental Protection Agency. (1997). The Preliminary Biennial RCRA Hazardous Waste Report (Based on 1995 Data). Washington, DC: U.S. Government Printing Office.

U.S. Senate. (1989). Report of the Committee on Environment and Public Works. Washington, DC: U.S. Government Printing Office.

Vig, N.J., & Bruer, P.J. (1982). The Courts and Risk Assessment. Policy Studies Review, 1 (4), 716-27.

Viscusi, W.K. (1982). The Informational Requirements for Effective Regulatory Review: An Analysis of the EPA Lead Standard. Policy Studies Review, 1 (4), 686-91.

White, M.C., Etzel, R.A., Wilcox, W.D., & Lloyd, C. (1994). Exacerbations of Childhood Asthma and Ozone Pollution in Atlanta. Environmental Research, 65, 56-68.

White, R.H. (1997, March). Will Political Process Allow EPA to Select Revised Standards that Adequately protect Public Health? EM Magazine, pp. 39-41.

Williamson, S.J. (1973). Fundamentals of Air Pollution. Reading, MA: Addison-Wesley.

Wolff, G. (1996, September). The Scientific Basis for a New Ozone Standard. EM Magazine, pp. 27-32.

Wood, B.D. (1988). Principals, Bureaucrats, and Responsiveness in Clean Air Enforcements. American Political Science Review, 82 (1), 213-34.

Wright, M., et. al. (1996). No Turning Back. Tomorrow (Vol. 5, Article 22). Boca Raton, FL: Social Issues Resources.

APPENDIX A

Ozone Alert! Employer Participation Survey I and Fax Notification Form
March 1995

Company Name:_____
Representative Name:_____

1) Have you heard of the OZONE ALERT! Program?
YES NO

2) Has your company participated in the OZONE ALERT! Program in the past?
YES NO

3) If yes, what OZONE ALERT! actions did your company take?
- ☐ Altered work schedules
- ☐ Encouraged employees to participate in carpools/vanpools or use public transportation
- ☐ Encouraged employees to bring their lunch to work
- ☐ Appointed a company Employee Transportation Coordinator (ETC)
- ☐ Other Actions (Please List)_____

4) Is your company interested in participating in the OZONE ALERT! Program this year?
YES NO

5) If yes, what OZONE ALERT! actions will your company implement?
- ☐ Alter work schedules
- ☐ Encourage employees to participate in carpools/vanpools or use public transportation
- ☐ Encourage employees to bring their lunch to work
- ☐ Appoint a company Employee Transportation Coordinator (ETC)
- ☐ Other Actions (Please List)_____

6) Would you like to participate in the OZONE ALERT! Fax Notification System which will notify your company by 4:00 p.m. the afternoon before an OZONE ALERT! day?
YES NO

Thank you for your participation. Please return this form to:

Glenn Travis, Air Quality Coordinator
INCOG
201 West 5th Street, Suite 600
Tulsa, OK 74103

Or fax your response to Glenn at (918) 583-1024.

Ozone Alert! Employer Participation Survey I Results
March 1995

1) Have you heard of the OZONE ALERT! Program?

YES	NO
86%	14%

2) Has your company participated in the OZONE ALERT! Program in the past?

YES	NO
34%	66%

3) If yes, what OZONE ALERT! actions did your company take?

- 5% Altered work schedules
- 83% Encouraged employees to participate in carpools/vanpools or use public transportation
- 78% Encouraged employees to bring their lunch to work
- 3% Appointed a company Employee Transportation Coordinator (ETC)
- 3% Other Actions

4) Is your company interested in participating in the OZONE ALERT! Program this year?

YES	NO
100%	0%

5) If yes, what OZONE ALERT! actions will your company implement?

- 15% Alter work schedules
- 85% Encourage employees to participate in carpools/vanpools or use public transportation
- 83% Encourage employees to bring their lunch to work
- 5% Appoint a company Employee Transportation Coordinator (ETC)
- 3% Other Actions

6) Would you like to participate in the OZONE ALERT! Fax Notification System which will notify your company by 4:00 p.m. the afternoon before an OZONE ALERT! day?

YES	NO
100%	0%

APPENDIX B

Ozone Alert! Employer Participation Survey II
July 1995

Company Name:_____
Representative Name:_____
Representative Phone:_____ **Fax:**_____

As you know, three OZONE ALERT! days have been called so far in 1995. Through the participation of employers such as you, Tulsa has avoided exceeding the ozone standard set by EPA. In recognition of excellence in local company OZONE ALERT! programs, the **Mayor's Cup Award** has been created. In order for your company to be considered for the Mayor's Cup Award, please complete the following survey. The information you provide may also be supplied to local media and publicized so that other companies and individuals can follow your example and join the fight against ozone pollution.

1) What OZONE ALERT! actions is your company taking during this ozone season?
__Altering work schedules / Flextime
__Encouraging employees to participate in carpools/vanpools or use public transportation
__Offering subsidies / preferential parking for carpoolers/vanpoolers
__Encouraging employees to bring their lunch to work or walk to lunch
__Catering staff lunches on OZONE ALERT! days
__Providing OZONE ALERT! information through internal publications
__Other Actions (Please List)_____

2) How many employees are participating in your OZONE ALERT! program?_____

3) What has been most helpful in implementing your company OZONE ALERT! program?
__Fax Notification
__Media
__Mailings such as "Tips for Marketing Your Company's OZONE ALERT! Program"
__Other (Please List)_____

4) What can INCOG do to improve your company's OZONE ALERT! program?
__Supply more OZONE ALERT! information through mailings
__Hold an Employers Meeting for area employers participating in the OZONE ALERT! program
__Speak at your company
__Other (Please List)_____

Thank you for your participation. Please fax this form to:
Glenn Travis, INCOG, (918) 583-1024

Ozone Alert! Employer Participation Survey II Results
July 1995

1) What OZONE ALERT! actions is your company taking during this ozone season?

60% Altering work schedules / Flextime
83% Encouraging employees to participate in carpools/vanpools or use public transportation
14% Offering subsidies / preferential parking for carpoolers/vanpoolers
57% Encouraging employees to bring their lunch to work or walk to lunch
10% Catering staff lunches on OZONE ALERT! days
73% Providing OZONE ALERT! information through internal publications
43% Other Actions

2) How many employees are participating in your OZONE ALERT! program?

Range from 6 to 1400

3) What has been most helpful in implementing your company OZONE ALERT! program?

95% Fax Notification
4% Media
1% Mailings such as "Tips for Marketing Your Company's OZONE ALERT! Program"
0% Other

4) What can INCOG do to improve your company's OZONE ALERT! program?

46% Supply more OZONE ALERT! information through mailings
28% Hold an Employers Meeting for area employers participating in the OZONE ALERT! program
15% Speak at your company
11% Other

VITA

Heather Lynn Turner

Candidate for the Degree of

Master of Science

Thesis: AIR POLLUTION CONTROL IN TULSA, OKLAHOMA: A CASE STUDY

Major Field: Environmental Science

Biographical:

Personal Data: Born in Taipei, Taiwan, on December 10, 1972, the daughter of Gregory Turner and Linda Anderson.

Education: Graduated from Nathan Hale High School, Tulsa, Oklahoma in May 1991; received Bachelor of Science degree, cum laude, in Environmental Policy from the University of Tulsa, Tulsa, Oklahoma in May 1995. Completed the requirements for the Master of Science degree with a major in Environmental Science at Oklahoma State University in July 1997.

Experience: Employed by the Indian Nations Council of Governments, Tulsa, Oklahoma, as an air quality staff person and environmental program coordinator, January 1995 to August 1997.

Professional Memberships: Air and Waste Management Association, National Association of Environmental Professionals.